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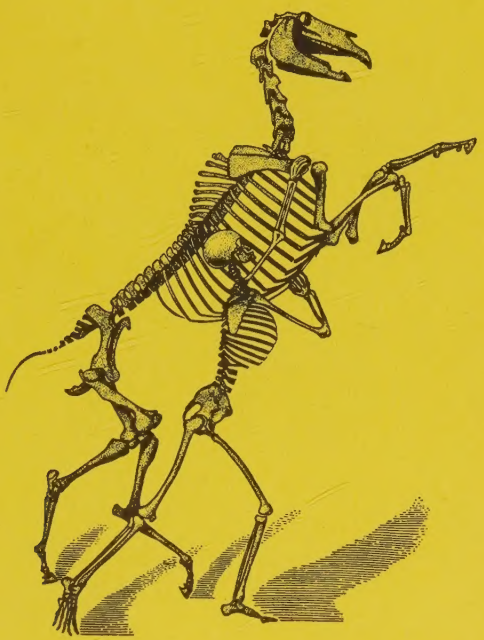

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THE FAUNA OF ALVASTRA

An Osteological Analysis of Animal Bones from a Neolithic Pile Dwelling.

Osteological Research Laboratory
University of Stockholm
S-171 71 SOLNA – Sweden

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THE FAUNA OF ALVASTRA

An Osteological Analysis of Animal Bones from a Neolithic Pile Dwelling.

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International Journal of Skeletal Research

1. Introduction

The bone material which is the basis of this study comes from a Middle Neolithic site, the Alvastra pile dwelling. The pile dwelling is situated at Alvastra in the province of Östergötland, southern Sweden, about 2.5 km from the eastern shore of Lake Vättern, about 4 km southwest of Lake Tåkern and less than one km from the Precambrian horst, Omberg. The whole area belongs to the most southwestern part of the Östgöta-plain. The area has, since Boreal times (about 7100 B.C.), offered good possibilities for human settlement (Magnusson 1964, p 29–38, Göransson 1986). The pile dwelling has thus a central position in one of the most

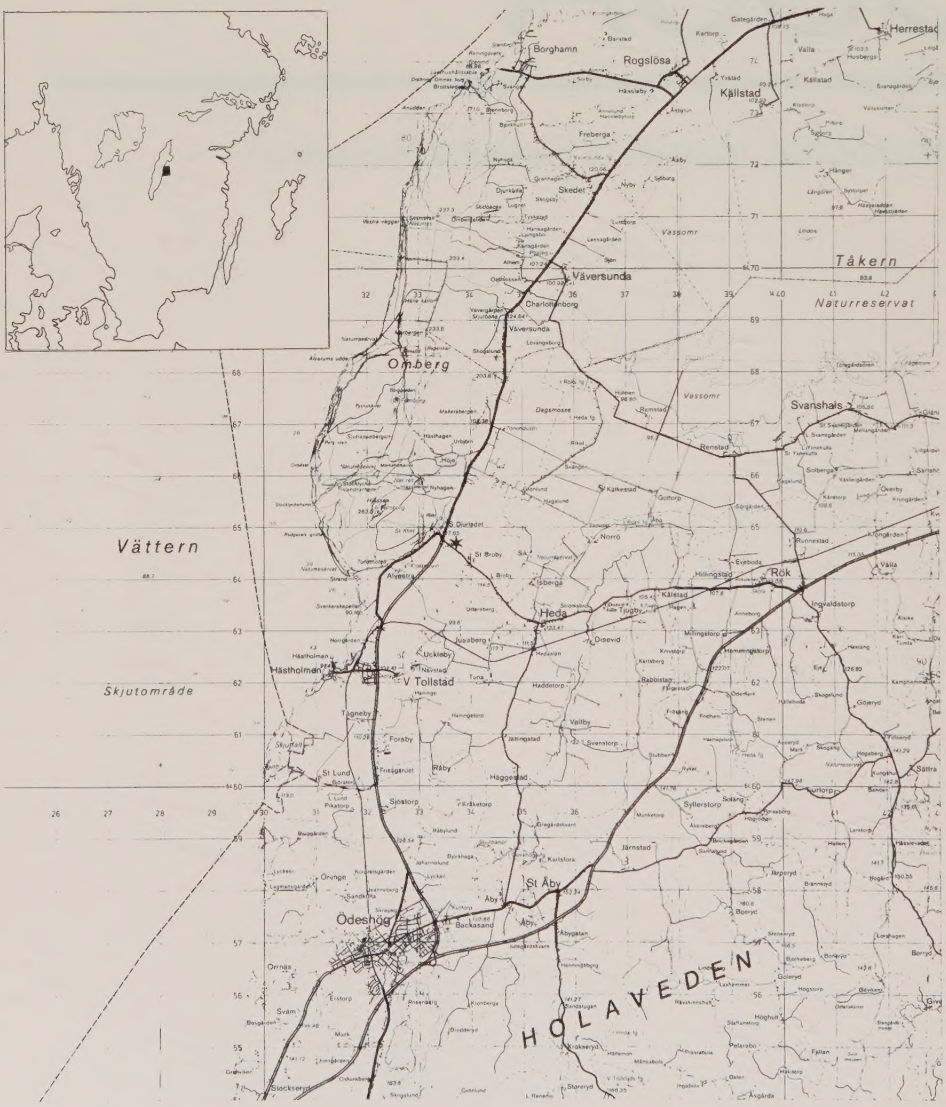

Fig. 1. Geographical position of the Alvastra pile dwelling (*). (Out of oficial map material from the National Land Survey of Sweden. Number of permission to reproduce 86.0028). One square of the grid = one square kilometer.

fertile districts of Sweden. There were also good hunting areas with Omberg in the vicinity and the woodland, Holaveden, in the south and good fishing waters, Tåkern, Vättern and many small rivers (Figs. 1 and 2).

Omberg
Alvastra
Alvastra pile dwelling
Alvastra spring mire
Väversunda
Charlottenborg
Lövängsborg
Dagsmosse
Torvindustri
Riket
Svängen
Källestad
Hagalund
Grönlund
Norrö
S Djurledet
St Broby
L Broby
Sik
Isberga
Heda
Tjugby
Disevid
Strömsbro
Jussberg
Uckleby
Näsvad
V Tollstad
Tuna
Haddetorp
Hedaslätt
Haninge
Haningetorp
Tägneby
Forsby
Jättingstad
Svenstorp
Vallby
Hästholmen
Norrgården
Skjutfält
St Lund
Friissgården
Råby
Häggestad
Björstorp
Uttersberg
Sverkerskapellet
Klosterruin
Naturreservat
Strand
Rödgavels grotta
Stocklyckehamn
Oxbåset
Älvarums udden
Skjutbacke
Skogslund
Makersbergen
Höje
Sjutrappebergen
Häsihagen
Urbjörn
Holmen
Ram
Sörtorpet
Disevidån
Vallby
Jättingstad
Svenstorp
Hedaslätt
Haddetorp
Tuna
Näsvad
Uckleby
Jussberg
Uttersberg
Isberga
Broby
Alvastra
Strand
Hästholmen
Tägneby
Haninge
Haningetorp
Forsby
Skjutfält
St Lund
Friissgården
Råby
Häggestad
Björstorp
Norrgården
Sverkerskapellet
Klosterruin
Naturreservat

This type of site is up to now unique in Scandinavia and, lying a little north of the 58th parallel, it is situated more than 1200 km from the numerous Alpine pile dwellings with which it is usually compared both in time and as regards construction (Malmer 1981, 1983, 1984, Malmer & Bartholin 1983). The term 'pile dwelling' denotes a type of ancient construction with the following characteristics:

1) many vertical wooden posts or piles and a horizontal platform,
2) situated in a bog, marsh or lake,
3) dating from Neolithic or Bronze Age.

The platform does not neccessarily need to be resting on piles; in Alvastra it rested directly on the peat or calcareous lake mud *gyttja* (Malmer 1981, 1984).

C 14-analysis places the pile dwelling in Middle Neolithic time, for example 4430 ± 85 B.P. (U-2735) (non-calibrated) which would correspond to about 3000 B.C. (calibrated). Several C 14-dates have given similar results (Malmer 1978, 1984). This time approximately corresponds to the later part of the early Sub-boreal period. The climate during the whole Sub-boreal period has been very much discussed, especially concerning precipitation. The most widespread opinion holds it to have been warm and relatively dry during the early part of the period becoming more wet towards the end. Whether the dry climate depended on low precipitation or high evaporation has not been decided on (Magnusson 1964, p 27). The climate is described (Berglund 1968, p 46) as more continental than in the previous, Atlantic period, that is the summer temperatures were higher, the winter temperatures colder and the precipitation lower.

The pile dwelling is situated in a spring mire, *Alvastra källmyr,* about 80 meters from dry land. In the north the spring mire partly borders the bog, *Dags mosse,* which is, from a botanical and genetical point of view, quite different composed than the mire (von Post 1916, p 227–243). The bog consists of reed *(Phragmites communis),* wild rosemary *(Ledum palustre)* and peat-moss *(Sphagnum squarrosum)* on the top of lake mud, *gyttja,* – a so-called Pinus-Ledum-Sphagnum bog. It is not calcareous. The spring mire is raised in a different way. It is fed with ground water from surrounding gravel deposits. The lowest layer is thick calcareous tufa over which there are layers of lime mud and peat *(Cladium Mariscus)* and reed. The area east of the mire and the bog was in ancient times a vast fen area but is today transformed into pasture and arable land (Göransson 1986). There are small rivers running in the area around the pile dwelling. Several of them run out into the south of Lake Tåkern. One of these is the stream *Disevidån* which delimits the former fen area in the east.

The Alvastra pile dwelling has been subjected to excavations in the years 1908–1919 and 1928–1930. Very little has been published from these excavations (Fröding 1910a, 1910b). Recent excavations have been carried out during summers and falls in 1976–1980 under the guidance of Professor Mats P. Malmer at the University of Stockholm. Some of the results from these excavations have already been published (Bartholin 1978, Malmer 1978, 1981, 1984, Malmer & Bartholin 1983).

The wooden construction of the site extends over more than 1000 square meters

and comprises more than a thousand vertical posts. Dendrochronological dating based on the oak piles shows that the pile dwelling was constructed within 42 years. These years can be divided in four periods of building activity: years 0–3, 10–12, 15–18 and 40–42 (Malmer & Bartholin 1983, p 24–25). The oak piles have

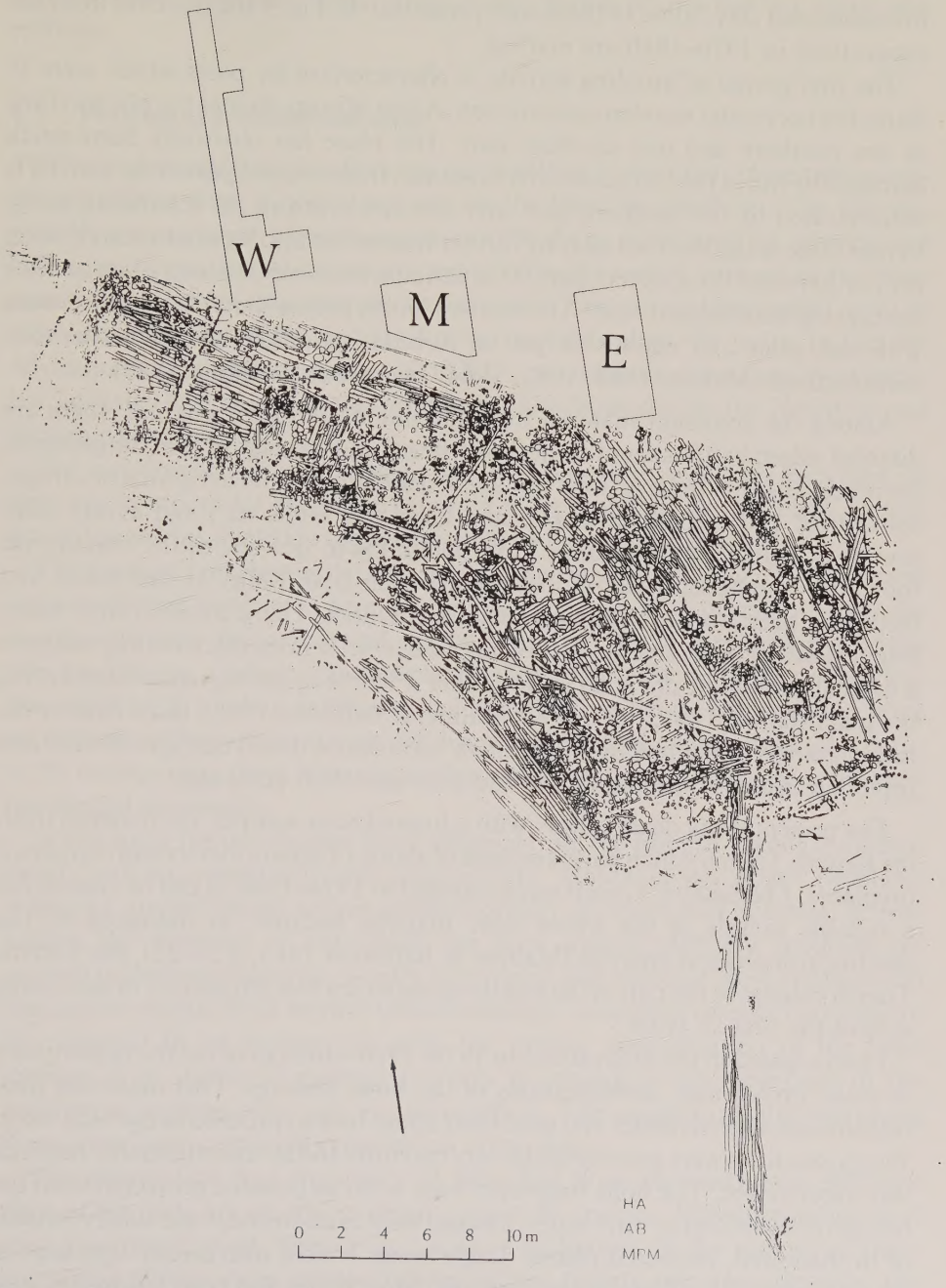

Fig. 3. Plan of the earlier excavations (1908–1919 and 1928–1930) of the Alvastra pile dwelling and the trenches excavated in 1976–1980.
E = EASTERN TRENCH; M = MIDDLE TRENCH; W = WESTERN TRENCH.

all started to grow at the same time. The first ones to be cut were about 40 years old (Bartholin 1978, p 217, Fig. 1, Malmer & Bartholin 1983). It has been suggested that they all were cut in a coppice wood (Göransson 1982, p 216). The extension of the earlier excavations is shown in Fig. 3. There are many fireplaces built of limestone and clay, some of them well preserved. In Fig. 3 the trenches from the excavations in 1976–1980 are marked.

The first period of building activity is characterized by posts which seem to frame the horisontal wooden construction. A line of posts divides the pile dwelling in one northern and one southern part. The place has obviously been much damaged by fire in the first years of its existence. In the second period the activity is concentrated to the southern part and consists probably of rebuilding work. Period three is signified not only by further repairs but also by expansions both in the northern and the southern part. This period is followed by a long pause, at least concerning building activities. The last and fourth period shows few signs of work with oak piles and cannot as yet be directly connected to the earlier pile constructions (Malmer 1981, 1983, 1984, Malmer & Bartholin 1983).

Among the abundant material from the pile dwelling excavations, there are doubled-edged battle-axes of stone, arrowheads and scrapers of flint, implements for producing fire, pottery, food remains (including carbonized grains of cereals, split, dried and carbonized apples and hazel-nut shells etc.) and a very large sample of animal bone remains. This material is in fact one of the richest ever found on a prehistoric site on the Swedish mainland. Many animal bones and teeth have been worked to artefacts of different kinds. There are also rather many fragments of human skeletons. It is a question, whether this pile dwelling has been a normal habitation site at all and whether it has been permanently used during the year (Malmer 1981, 1983, 1984, Malmer & Bartholin 1983). But whatever the interpretation of the pile dwelling, there is no doubt that it can give us rich and profound insights into human life and activities 5000 years ago.

The present study deals mainly with a limited bone sample, the material from the Eastern Trench which covers an area of about 15 square meters and contains 8 fireplaces. The Eastern Trench was excavated in 1976–1980. It can be considered a suitable sample of the whole bone material because, as indicated by the dendrochronological analysis (Malmer & Bartholin 1983, p 24–25), the Eastern Trench belongs to the part of the pile dwelling which was intensively in use during at least the first 18 years.

I participated in the excavations in 1978–1980 which gave me the opportunity to make preliminary identifications of the bone findings. This made the final osteological analysis easier and gave hints about how to proceed in the field work. The excavations were accomplished very carefully and all unearthed soil/material was water-sieved. The bone fragments were as far as possible protected from the hot sun or even kept in mire water, cleaned with caution and dried slowly indoors or in shadowed, protected places. Single bones broken into pieces were kept in separate bags to facilitate further analysis. Most bones and bone fragments were well preserved by the calcareous water in the mire and could be dried without cracking. Some fragments were preserved in polyethylene glycol

($CH_2OHCH_2OHCH_2OH$ . . .). The bone material was very fragmentary and whole bones or bone elements suitable for measuring were not common. The position of every human bone, bone object and every worked fragment was registered three-dimensionally. All identified or identifiable animal bones were, together with fragments larger than 5 cm, drawn or marked on plans and sections.

1.1 Framing of problems and aims

The bone material from the Alvastra pile dwelling is one of the largest osteological collections from a prehistoric site on the Swedish mainland. The site was used by a population whose economy was based on both farming, hunting and fishing and consequently there are many different species present in the bone material. Moreover this material accumulated, from an archaeological point of view, during a very short period of time, probably about 50 years. In fact the Alvastra material, dated to about 3000 B.C., provides the richest and most detailed 'snapshot' we have hitherto obtained of the fauna during the Neolithic and Bronze Age in Sweden.

The calcareous Alvastra spring mire has, generally speaking, provided an ideal environment for the preservation of bone material. Nevertheless, certain general problems related to taphonomy will be noted and discussed.

The Eastern Trench sample consists of only a small part, about 6%, of the total excavated bone material. There are thus various reasons to discuss whether the sample currently being analysed can be considered to be representative of the pile dwelling as a whole. One important fact is that the material studied was excavated with modern methods, including water-sieving. Some of the bone material from the earlier excavations was analysed at the beginning of this century. In various ways there is reason to discuss differences and similarities between the old and new results.

In this study the non-human bone material from the Eastern Trench is investigated both quantitatively and qualitatively. Consequently some problems related to quantification within archaeozoology are examined in detail. In estimating the numbers of individuals for each species, different methods are applied to the bone material in order to compare and evaluate these methods and discuss the results. With respect to methodology, a statistical model is applied to the material in an attempt to assist the precise quantification of the bone remains. The statistical method attempts to provide a new approach to the problem of determining species composition. The question of distinguishing sheep from goat is especially considered in this way.

The distribution and frequency of identified bone elements from different parts of the body are studied in detail, species by species. This distribution is of great importance with respect to a critical evaluation of the sources of these bones and of their taphonomy. Taking culture history into consideration, the distribution is important because it provides valuable facts by which to estimate the ways in which man has used the fauna. The distribution may also indicate

where butchering and other techniques were carried out, whether *in* or *outside* the site, and if *whole* or only *parts* of animal carcasses are represented. All these taphonomic and cultural aspects have considerably significance in establishing how representative the bone material is in relation to the actual fauna of that time.

The nature of the ecosystem and the different biotopes present in the region of the pile dwelling are discussed in relation to the vegetational history of the area and also with respect to each identified species and its preferences and needs. An important question is whether hunting and fishing took place in the neighbourhood of the site, or if people were forced to undertake extended hunting expeditions. The occurrence of various animal species and their relative frequencies are compared with and tested agianst earlier, as yet unpublished, analyses of bone material from the pile dwelling, together with other Scandinavian bone samples from different prehistoric sites and periods, as well as from the Middle Ages and modern times. Comparisons are also made with the existing local fauna and biotopes.

The possible occurrence of aurochs in the material, as well as pig in an early stage of domestication, are investigated. Age assessments, possible alternative periods for slaughter, hunting and fishing have all been used in an attempt to establish seasonal use of the pile dwelling.

The bone material shows the effects of different kinds of activities. I have tried to distinguish between human and other animal activities and also to distinguish these activities from other, natural effects, on the bone material. The human activity can potentially be in the form of skinning, butchering, marrow extraction and the manufacture of bone objects. Various different working methods can be distinguished, but in the present study this group of problems is only briefly considered. This is similarly the case with gnaw marks and evidence of other animal activity. A detailed investigation of these matters will be published elsewhere.

The bone artefacts are also dealt with separately, since the selection of particular species and the kinds of bone element used in the manufacture of implements and ornaments must have been undertaken on criteria other than for the selection of animal bodies for food. Different manufacturing methods can be made out, but again this complex group of problems will be considered elsewhere.

The human skeletal material is only discussed briefly. It should, however, be noted that the specimens do not show any distinct marks indicating injuries, made by weapons or otherwise.

1.2 A general survey of the bone material from the Eastern Trench

The bone material contains more than 87000 fragments and has a total weight of about 43 kg. It emanates, as already has been pointed out, from a small part of a large site and is consequently a small sample of the large amount of bone material, about 700 kg, collected in connection with excavations of the pile dwelling. The main part of the bone material from the Eastern Trench, 97.4 % by weight, consists of animal bone fragments, being unburnt, burnt or only damaged by fire,

while just a small part, 2.6 % by weight, consists of unburnt human skeletal fragments (Table 1). The more or less fragmented, worked bone objects, 120 pieces with a total weight of about 600 g, have been analysed separately since they can be considered as made by man from especially selected material (Malmer et al.). Table 76 (Section 7.1.19) shows the distribution of 64 bone artefacts identified to bone element and species.

Table 1. The distribution of weight and % by weight of the animal bone material and the human skeletal material.

The bone material	**Weight**	
	g	%
Animal bones from the cultural layer	41796.9	97.4
Animal bones from the post holes	53.4	
Human skeletal material	1129.0	2.6
Total	42979.3	100.0

The animal bone fragments have been collected in all regions of the trench and at all levels of the cultural layer. Considering weight and extent of identification the unburnt material dominates. On the other hand, considering number of fragments the burnt material dominates, with the main part consisting of more than 59000 bone fragments unidentified to particular bone element and species (Tables 2–3). All animal bone material, unburnt, only damaged by fire or burnt, is

Table 2. The distribution of unburnt, damaged by fire and burnt, charred, bone material* with respect to the distribution of the identified material.

	The total material			**The identified material**		
	Weight		**Number**	**Weight**		**Number**
	g	%	n	g	% **of total**	n
The animal bone material	41796.9	100.0	>87000	17589.4	42.1	4414
unburnt	25303.1	60.5	19870	16106.2	63.7	3159
damaged by fire	3932.6	9.4	7374	543.4	13.8	314
burnt	12561.2	30.1	>60000	939.8	7.5	939
The human skeletal material						
unburnt	1129.0	100.0	643	1103.0	97.7	403

*NOTE. The bone material from the post holes, 53.4 g, is not included and is accounted for in Table 3.

Table 3. The distribution of the animal bone material from the post holes.

	The total material			**The identified material**		
	Weight		**Number**	**Weight**		**Number**
	g	%	n	g	% **of total**	n
The animal bone material	53.4	100.0	> 150	20.8	39.0	10
unburnt	36.9	69.1	70	20.2	54.7	7
damaged by fire	3.0	5.6	7	–	–	–
burnt	13.5	25.3	> 70	0.6	4.4	3

distributed all over the trench but with varying density both horisontally (Fig. 4) and at all levels. The human skeletal material is distributed with clear concentration to certain squares (Fig. 5) and levels.

Fig. 4. The Eastern Trench. Distribution of the number of fragments (>87 000) of the total animal bone material.
1. UNBURNT; 2. DAMAGED BY FIRE; 3. BURNT.

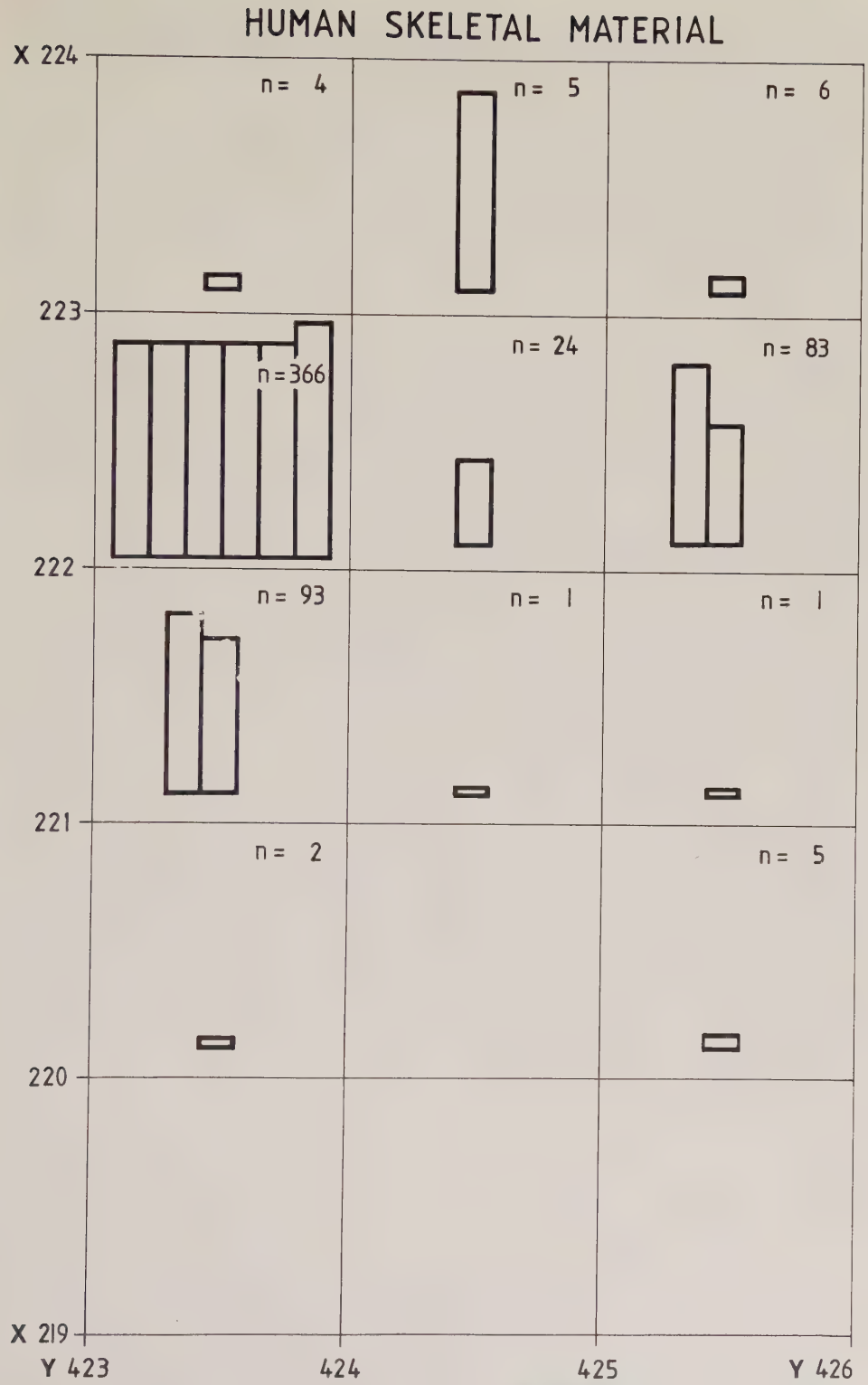

Fig. 5. Distribution of the fragments (643 pieces) of the unburnt human skeletal material.

The colour of the unburnt animal bone material varies between light brown and greyish brown to deeply black or red brown. By the designation 'damaged by fire' is meant fragments which have been subjected to fire only on certain parts or incompletely and which, because of this, show black burnt patches. The colour of the unburnt human fragments ranges from greyish brown to brown.

The burnt animal bone material is mainly charred white. Hence the main part of the burnt material is considered to be highly burnt. There are only a few fragments showing a proportion of blue or blue-grey areas, probably traces of incomplete combustion, showing that organic matter still survives in those parts (Gejvall 1963, p 469).

The degree of preservation of the material is good but the degree of fragmentation is high. Some whole teeth but only a few more or less whole bone elements are present in the material. Concerning the unburnt and unidentified animal bone material, 16774 pieces, the size of the fragments varies from about 0.5 cm to about 11 cm, concerning the material damaged by fire and unidentified, 7067 pieces, from about 0.5 cm to 5 cm and finally concerning the burnt and unidentified material, more than 59000 pieces, from about a couple of mm to about 4 cm. Most fragments of the burnt material have a size of 0.5 cm or less. Similarly, among the human skeletal remains, the number of whole or nearly whole bone elements are very few. With respect to the human skeletal fragments unidentified to specific bone element, 240 pieces, the size of the fragments varies from 0.5 cm to about 2 cm. If possible broken parts have been glued together.

In this study the human skeletal material will not be further discussed. It will be dealt with in the forthcoming publication of the Alvastra pile dwelling (Malmer et al.).

Despite the fragmentation of the animal bone material various measurements have been possible to take on teeth and bone specimens (Chapter 7, Tables 33–75). Isolated lesions, degenerative joint disorder, healed fractures and anomalies have been observed on single bone elements of cattle, elk, pig and badger (Sections 7.1.1, 7.1.3, 7.1.6, 7.1.10). About 2 % of the total animal bone material show clear marks of human activity, probably indicative of butchering, skinning and marrow extraction (Table 4). About 5 % of the total animal bone material show clear gnaw marks from mammal teeth (Table 5). The distributions of specimens with cut marks and gnaw marks which have been identified to species and bone type are shown in Tables 77 and 78 (Section 7.1.19).

Table 4. The distribution of **Cut marks** etc. on identified and unidentified unburnt, damaged by fire and burnt animal bone material.

	The total animal bone material* (41850.3 g)			**Fragments with cut marks** (706.0 g)		
	Weight		**Number**	**Weight**		**Number**
	g	%	n	g	% of total	n
The identified material	17610.2	42.1	4424	554.0	3.1	22
unburnt	16126.4	63.7	3166	528.7	3.3	19
damaged by fire	543.4	13.8	314	25.1	4.6	2
burnt	940.4	7.5	943	0.2	0.02	1
The unidentified material	24240.1	57.9	> 82700	152.0	0.6	57
unburnt	9213.6	36.3	16774	139.5	1.5	46
damaged by fire	3392.2	86.2	7067	6.6	0.2	5
burnt	11634.3	92.5	> 59000	5.9	0.1	6

*NOTE. The bone material from the post holes is included.

Table 5. The distribution of **Gnaw marks** etc. on identified and unidentified unburnt, damaged by fire and burnt anmimal bone material.

	The total animal bone material* (41850.3 g)			**Fragments with gnaw marks (2005.0 g)**		
	Weight		**Number**	**Weight**		**Number**
	g	%	n	g	% of total	n
The identified material	17610.2	42.1	4424	1485.7	8.4	94
unburnt	16126.4	63.7	3166	1405.4	8.7	84
damaged by fire	543.4	13.8	314	75.0	13.8	8
burnt	940.4	7.5	943	5.3	0.6	2
The unidentified material	24240.1	57.9	> 82700	519.3	2.1	234
unburnt	9213.6	36.3	16774	469.1	5.1	195
damaged by fire	3392.2	86.2	7067	16.5	0.5	13
burnt	11634.3	92.5	> 59000	33.7	0.3	26

*NOTE. The bone material from the post holes is included.

1.3 A survey of the animal bone material

Four thousand four hundred and twenty-four fragments, 17.6 kilos, 42 % by weight of the cleaned and dried animal bone remains proved suitable for closer identification to specific bone elements and species or group of species. The designation 'group of species' needs further explanation. If, in analysing bone material, two or more species which are skeletally similar to one another are identified, there are often fragments which can only be identified as belonging to the group of these closely related species without the possibility of identifying

them precisely to one species in particular. In this analysis the bone elements of mammals, birds and fishes which have not been possible to identify with respect to species have been 'grouped' according to family or higher taxon (van den Brink 1958, Bruun & Singer 1975, Muus & Dahlström 1981).

The mammals compose 18 species and four major taxonomic groups, the birds seven species and two major taxonomic groups and the fishes eight species and one major taxonomic group. Hence there are a total of 33 species and seven groups represented in the material. The distribution of species in number of fragments and weight are given in Table 6. With respect to pig it denotes both the remains of

Table 6. The weight and number of fragments of mammals, birds and fishes identified in the material.

Mammals

Species	Weight g	Number n
Cattle	11121.7	1260
Sheep	138.6	62
Sheep/Goat	61.0	59
Elk	205.3	21
Red deer	1279.8	183
Roe deer	53.9	7
Pig	1506.4	937
Wolf	15.9	6
Dog	1.2	3
Brown bear	333.6	4
Badger	31.7	36
Pine marten	39.5	115
Lynx	4.5	2
Wild cat	11.2	26
Beaver	10.4	6
Mountain hare	2.5	12
Ground vole	3.3	22
Field vole	1.1	8
Common shrew	0.1	1
Total	14821.7	2770

Birds

Species	Weight g	Number n
Crane	4.3	2
Heron	0.2	1
Capercaillie	0.3	1
Teal	0.2	1
Wood pigeon	0.2	1
Meadow pipit	0.1	1
Tree pipit	0.3	1
Total	5.6	8

Fishes

Species	Weight g	Number n
Pike	40.1	102
Perch	4.3	47
Whitefish	4.6	41
Bream	16.0	92
Tench	0.4	4
Roach	0.5	5
Rudd	0.5	5
Ide	0.2	1
Total	66.6	297

wild boar and domestic pig. The question of a distribution of the pig bones among wild boar and domestic pig is discussed later on (Section 7.1.6).

The distribution of bone material among major taxonomic groups is given in number of fragments and weight (Table 7). In addition to the species identified in this study further species have been identified (Table 8) in connection with published and unpublished analyses of animal bone material from earlier excavations within the area of the pile dwelling (Pira 1910, Hedell 1909–1913, 1919, Ekman 1977).

Concerning weight the cattle, Domestic *Bos*, represent about 63 % of the total identified material and are the most common species in the material, followed by

Table 7. The weight and number of fragments of bone material identified to major taxonomic group or to fish and bird species only.

Mammals

Group	Weight g	Number n
Elk/Red deer	27.7	10
Big ruminants (Cattle, elk, red deer)	2554.3	1037
Small ruminants (Sheep, sheep/goat, roe deer)	99.8	150
Canid/Feline family	2.2	3
Total	2684.0	1200

Birds

Group	Weight g	Number n
Meadow-pipit/ Tree-pipit	0.1	1
Wild duck species	0.7	2
Bird species	0.6	4
Total	1.4	7

Fish

Group	Weight g	Number n
Carp family	4.6	55
Fish species	5.5	77
Total	10.1	13

Table 8. Earlier identified species in bone materials from the pile dwelling and not represented in the Eastern Trench material.

Mammals	Birds	Fishes
Species	**Species**	**Species**
Otter	**Golden eagle**	**Wels**
Hedgehog	**Marsh harrier**	**Silver bream**
Red squirrel	**Honey buzzard**	
	Tawny owl	
	Woodcock	
	Mallard	
	Pintail	
	Wild goose	
	Whooper swan	
	Swan	

pig representing 8.5 % and red deer representing about 7 %. As to number of fragments the cattle represent 28.5 % of identified material followed by pig with 21 % and red deer with 4 %. Among the fur animals pine marten, badger and wild cat are the most common species.

The degree of accumulation and concentrations of animal bones vary considerably within the trench both horisontally and vertically. As regards the mammals the horisontal and vertical distribution of different species or combinations of species differ, sometimes quite remarkably. As an example of the disparity of the horisontal distribution of mammals, Fig. 6 shows this distribution with respect to the meat producing mammals. As an example of the variation of accumulation vertically, Fig. 7 shows this distribution with respect to cattle. In a forthcoming Alvastra publication this group of problems will be discussed more thouroughly. The bird bones are few, only 0.04 % by weight and 0.4 % by number of the total

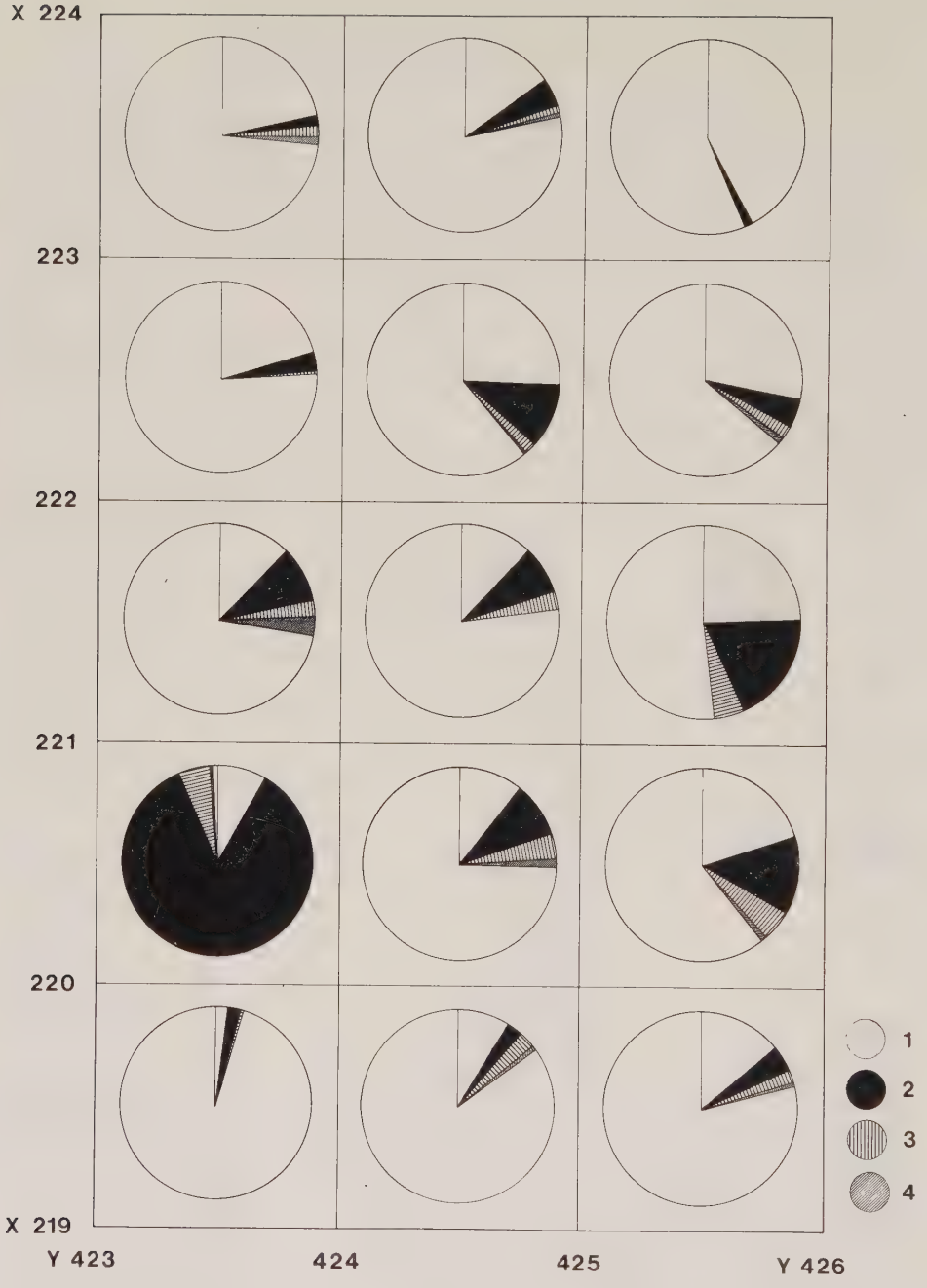

Fig. 6. Distribution of the fragments of meat-producing mammals.
1. CATTLE (1260 pieces); 2. PIG (937); 3. SMALL BOVIDS (121); 4. CERVIDS (221); 5. BROWN BEAR, BADGER, BEAVER and MOUNTAIN HARE (58).

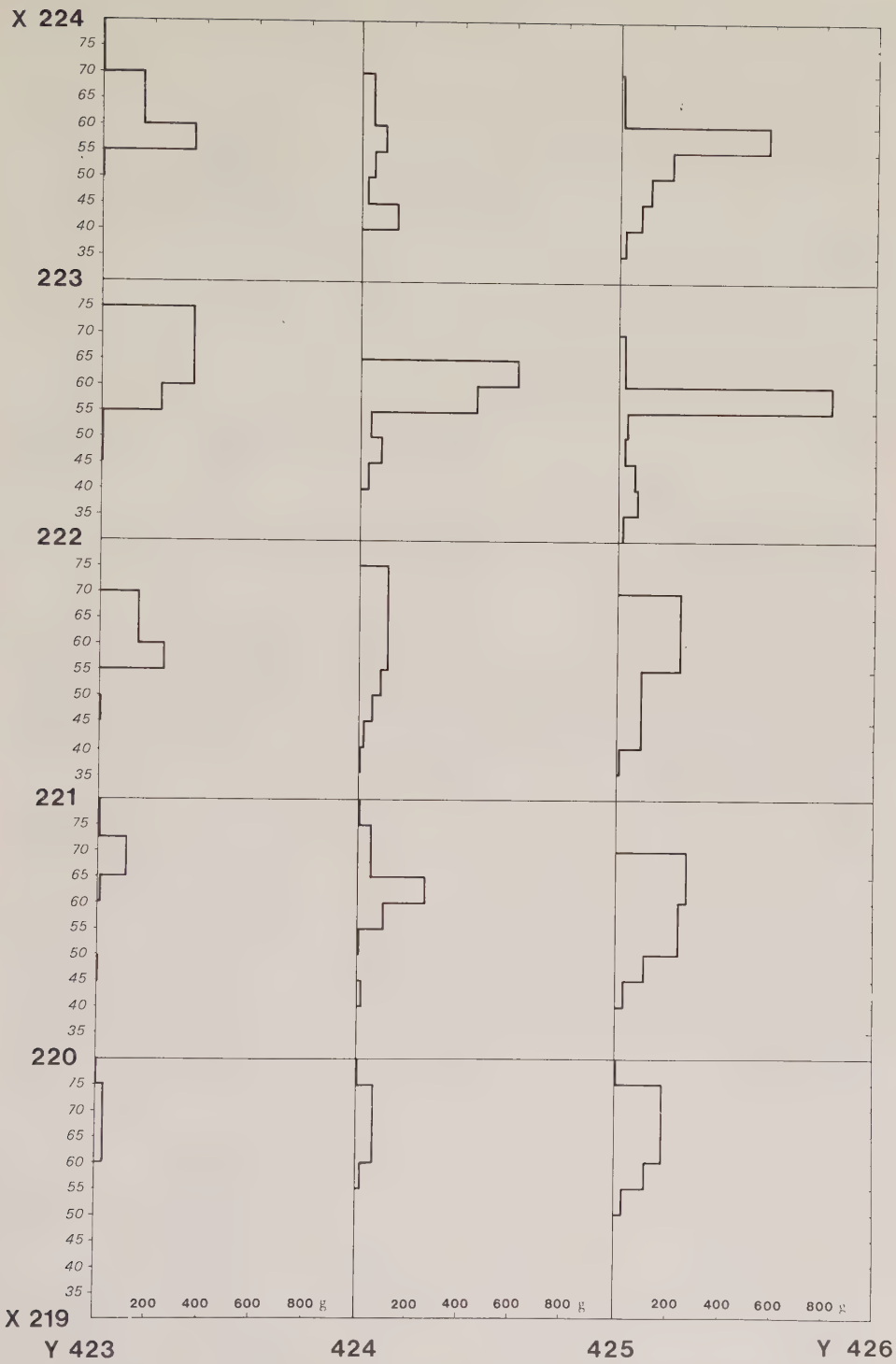

Fig. 7. Vertical distribution of the CATTLE remains with respect to weight (11 121.7 g). The distribution is shown as a function of depth given in gram per 5 cm.

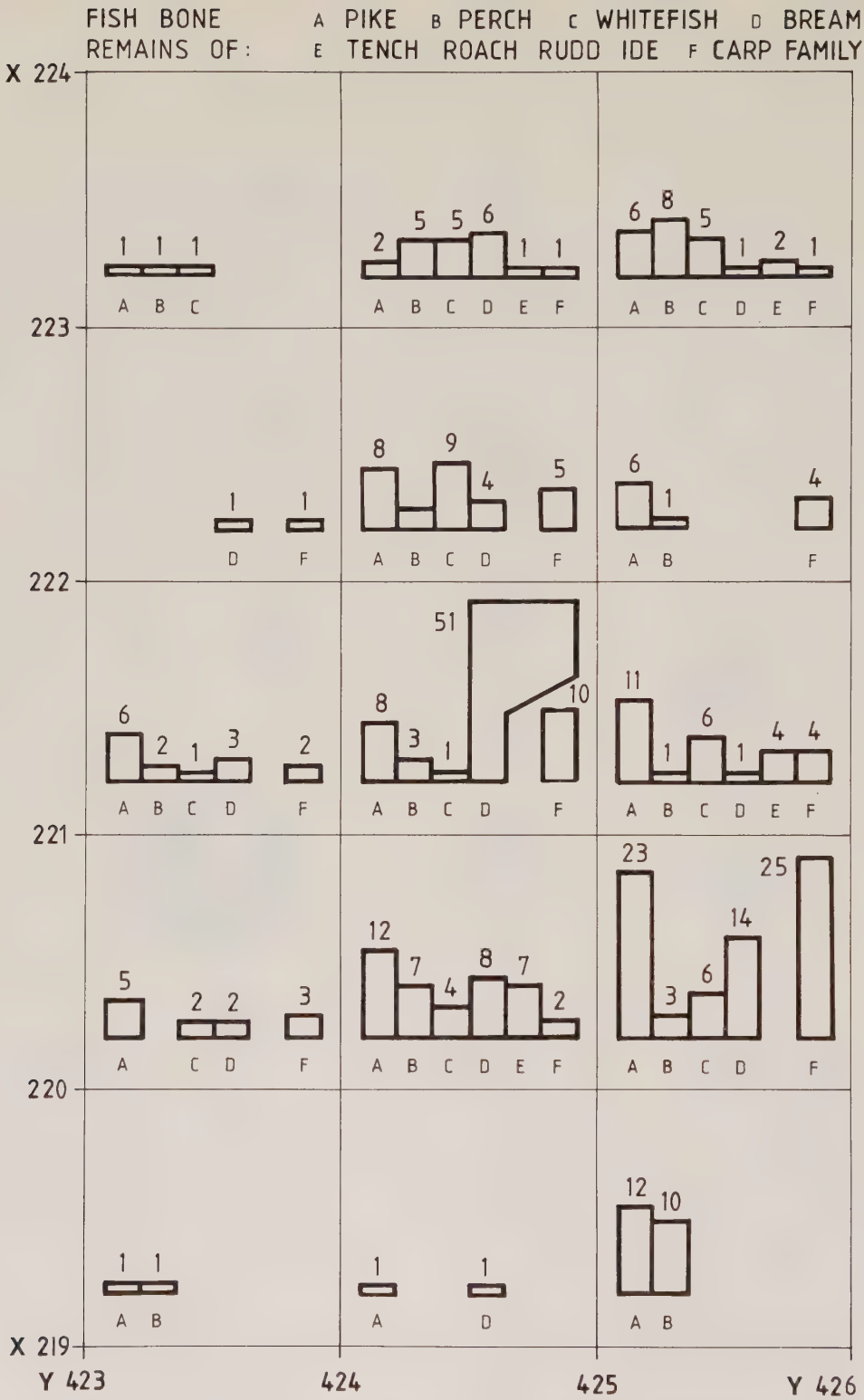

Fig. 8 Distribution of fish bones identified to species or major taxonomic group. 1. PIKE (102 pieces); 2. PERCH (47); 3. WHITEFISH (41); 4. BREAM (92); 5. TENCH, ROACH, RUDD and IDE (15); 6. CARP FAMILY (55).

identified material. The remains occur, however, horisontally distributed over the trench in upper as well as lower layers. As to weight the fish bones represent only 0.4 % of the total identified material, as to number of fragments about 10 %. The pike and the bream are the most common species. Put together the carp family is the largest. Also the degree of accumulation of the number of fish bones within the trench varies both horisontally (Fig. 8) and vertically.

The animal bone material from the pile dwelling thus probably represents food debris to a large extent. It can as a whole be considered as an anthropogenic thanatocoenosis, that is a 'death assemblage' created by the Neolithic people who used the pile dwelling and it gives us a good idea of the animal life in the catchment area of the site, but it is important to remember that the identified species in an archaeological sample reflect a human choice (Lepiksaar 1982, p 105). Hence they do not neccessarily represent all species existing in the surroundings of the site in the Middle Neolithic.

2. Taphonomic and other factors and their relationship to quantification

2.1 Taphonomy

Remains of prehistoric organic material undergo long and complex environmental influences. Taphonomy examines post-mortem relations between organic remains and their external environment, and is a detailed study of the transition of, in this case, animal bone remains from the biosphere (life community above earth) into the lithosphere (death community in earth) (Efremov 1940, Lawrence 1968). The animal bone material has in this connection been exposed to two different kinds of processes, subdisciplines of taphonomy, a biostratinomic process and a diagenetic process. The biostratinomic process takes place between the death of an animal and its final burial. The diagenetic process, chemical and physical changes, takes place between burial and discovery/excavation and collection. The study of these two fields are combined in the science of taphonomy (Efremov 1940, p 85, Lawrence 1968, p 1315–1317, Fig. 1, Lawrence 1971, p 594, Noe-Nygaard 1977, p 218–219). To analyse and evaluate taphonomic, that is, postmortem factors and their effects are of great importance for palaeoecology, neglecting them leads to error in the results. Palaeoecology, with its focus upon interrelationships in the geologic past between living organisms and their surroundings, has thus as its ultimate goal the reconstruction of ancient communities. A major aim of the analysis of faunal remains from archaeological sites is to try to reconstruct the ecology of early man. Such reconstructions certainly benefit from carefully accomplished taphonomic studies of archaeological deposits (Efremov 1940, Lawrence 1971, Noe-Nygaard 1977). It should be stated that the causes of bias in buried bone assemblages are numerous. Gilbert & Singer (1982, p 22–29, Table 1) give an informative but generalized history of an archaeological faunal collection and manifestations of potential depositional biases.

Taphonomic effects on animal bone material have been the subject of several studies which have deepened our knowledge and understanding of natural as well as by human beings or animals caused action on analysed bone material.

The study and analysis have had as object such effects of biostratinomic processes as skinning, butchering and marrow extraction (for example Gejvall 1969, Bonnichsen 1973, von den Driesch & Boessneck 1975, 1979, Noe-Nygaard 1977, Hill 1979, van Wijngarden-Bakker 1980, Binford 1980, Sammons et al. 1981). Effects of bone chewing and gnawing by animal teeth, natural disarticulation due to anatomical construction and the inherent structure of the bone itself, weathering, abrasion, drying, root-etching and trampling have also been studied (for example Gejvall 1969, Sutcliffe 1973, Behrensmayer 1975, 1978, Brothwell 1976, Hill 1976, Shipman & Phillips 1976, Haynes 1980a, 1980b, 1981, 1983a, 1983b, Myers et al. 1980, Binford 1981, Shipman 1981, Lepiksaar 1982).

Also diagenetic changes in animal bones have been studied. The major components of bone tissue are protein (organic material) and mineral (inorganic material). The relationship between these two types of materials influences the strength of the bone. In the living animal the bone cells are chemically active, creating a dynamic tissue which participates in the physiology of the animal. After death the tissue continues to react, responding to intrinsic factors, that is the chemical structure and reactivity of the tissue and extrinsic factors, that is the immediate environment of bone after death. Such actions, which determine the rate of bone diagnesis, have varying effects (Endt & Ortner 1984). To this must be added that all different bone elements in a skeleton do not have the same structure, some of them consist of more compact bone tissue than others and they are, because of this, more resistent to various taphonomic processes. Furthermore, bones from young animals consist generally of more spongy tissue than bones from adult animals and decompose more easily.

In connection with cremation and combustion the organic material more or less disappears, which means that burnt bone material possesses more resistance to disintegration and has greater survival chances when buried in earth. It can generally be said that calcareous and alkaline soils will preserve bone material, above all unburnt material, while acid soils accelerate the decomposition. Hence the bone material from Alvastra pile dwelling had very good conditions for preservation, since the site is situated in Alvastra spring mire which is calcareous.

It has been demonstrated on both empirical and theoretical grounds that the survivorship of sheep bones is a function of their density, that is specific gravity. This density varies among the different bone elements. For example scapula, distal humerus and proximal radius have a higher value and resist destruction better than other bone parts in the front leg. It is argued that this model for sheep can be applied to other artiodactyla (Binford & Bertram 1977).

Laboratory experiments have been conducted, which stimulate the effect of temperature and fragment size on the rate and nature of disintergration of animal bone material in archaeological sites. These experiments analyze the effect of bone size or volyme and temperature on the diagenetic process. They

demonstrate the importance of two wellknown concepts in connection with taphonomic effects on bone material: 1) The rate of chemical decomposition of bone tissue is related to the temperature and to how large an area of bone has been exposed to chemical attack. This means the higher the temperature the faster the destruction, and that tissue near the surface may differ chemically from tissue away from the surface. 2) In general small bones are not preserved as well as big ones, which might signify an under-representation of small animals in faunal assemblage (Endt & Ortner 1984).

As regards diagenetic processes Lepiksaar (1983, p 115–116) has claimed that local and favourable constellations of the soil can prevent an advanced disintegration of bone material, which for example has been buried in acid sandy soils.

It should, however, also be emphasized that the conditions of preservation vary not only between different bone elements or parts of a bone element but also among species. In this respect, one could give the example of wild or domestic pig in comparison with, for instance, cattle and red deer. The loss of pig bones is usually explained by their high fat content, which make them desirable for dogs and wild animals, including birds, feeding on the carcasses (for example Lepiksaar 1982, 105, 113). Furthermore, the bones of pig have extensive cartilaginous parts which make them attractive to chewing by animals. In addition the fat accelerates in general the decomposition of bone. Suggestions have also been made that many limb bones of for example wild boar have relatively short, curved diaphyses (shafts) less suitable for making implements and that this may have resulted in a more careless fragmentation. Furthermore, being short but rather solid long bones, they may be more difficult to break than bones from for instance red deer. All this might have led to a more pronounced fracturing of the bones, resulting in smaller fragments which in general are more disposed to diagenetic processes (Noe-Nygaard 1977, p 234).

Other authors discuss two conflicting interpretations of prehistoric faunal assemblages, the recurrent problem of distinction between the result of human behaviour and the actions of carnivores, by observation of modern assemblages and the evaluation of frequency tables. This technique of faunal analysis was not able to detect differences and the authors thus suggest extreme caution when interpreting the taphonomic history of the animals on these conditions (Shipman & Phillips-Conroy 1977). In intra-site studies frequency tables have been used successfully to show how anatomical selection can be used to trace hunting tactics. Whether animals were slaughtered and brought back to the site or hunted, killed and butchered elsewhere (when hide from the animals was used as a container for carrying the meat home) thus demonstrating the 'schlepp effect'. Apparently the feet were left attached to the hide since they made convenient handles for dragging or carrying (Perkins & Daly 1968, p 104). Perkins & Daly (1968) and also other authors, for example, Lepiksaar (1974) have used such studies of frequency tables to distinguish 'permanent' settlements from 'kill sites'.

However, it should also be emphasized that the frequency of bone specimens can also be affected by what kind of bone specimen has been considered to be ideal in connection with the manufacture of implements, weapons and ornaments. Food taboos may also have existed. Furthermore, certain parts can have been removed and put aside for food storage and perhaps salted, dried, smoked or kept in one way or other for later preparation and consumption. The effect of the above mentioned biostratinomic and diagenetic processes, which may have affected the animal bone material from the Eastern Trench, is further discussed in the following chapters of this study.

2.2 Other factors

Taphonomic factors are, as discussed in the preceding section, of great and urgent importance when making an archaeozoological analysis and have also been subject to various studies.

There are, however, some other factors which may also have a great influence on the quantitative representation of different species that have existed in the actual area, as well as on the number of skeletal specimens and the relative frequency of identified species in the analysed bone sample. Such factors need to be pointed out and do not in general seem to be discussed in connection with archaeozoological analyses of faunal remains. These are factors which cannot be discovered by simply examining the actual bone sample. Perhaps some examples should be given.

A large forest fire will for example change the habitat completely. The dark low-productive forests are replaced by productive open grassland, followed by bushes, coppice-woods of young trees and after 50 to 150 years dark dense forests again. During these succession stages the composition of game species as well as the total biomass will change drastically (Odum 1966, p 97–99). Especially in the first decades after a forest fire the variation in food supplies must for instance have affected the number of cattle existing in the area, since cattle are favoured by the open grassland.

Besides these long-term changes many wild animals, such as grouse, ptarmigans, hares and rodents (for example voles and red squirrels) fluctuate dramatically in numbers with a periodicity of 4 years or 10–11 years (Keith 1963, Elton 1942). The variation in numbers of these species will also severely affect the populations of their predators. Investigations of the modern Swedish red fox and its prey animals, the voles, show such effects. During peak years for voles the number of foxes will increase and vice versa, at least in unstable environments, such as today's northern Sweden where the amount of alternative food is low (Englund 1970, 1980).

Furthermore, serious diseases of an epidemic kind affect at times both domestic and wild mammals and decimate severely their numbers. As examples the number of cattle and other bovids may have been strongly reduced by epidemics such as rinderpest, *pestis bovina,* (Schmiterlöw 1975, p 72–73) and anthrax (Siegel 1973, p 374). As a result, man has, in such periods, become more reduced to game hunting for his meat supply. As regards the living wild mammals, foxes

may, in a very short time, be nearly completely wiped out by rabies. Epidemiological studies of fox rabies in Europe have shown that rabies virus is a very old parasite dating back to 2300 years B.C. in ancient Babylon. Other wildlife, for instance roe deer and badger, can catch the infection and so can also domestic animals such as cattle, sheep and dogs. Among all these animals the incidence is, however, relatively low (Steck & Wandeler 1980, p 71, 75, 91).

Consequently, it is here argued that the bone material from Alvastra pile dwelling, dated to a short period in the Middle Neolithic time, may also reflect such factors of a non-taphonomic kind. Maybe factors of this kind can, for instance, contribute to an explanation of the apparent total or nearly total lack of skeletal remains of species such as the red fox and the red squirrel in the bone material from the Eastern Trench and in the other analysed bone materials from the site, which are referred to later. It is assumed that the biotopes existing in the region during the actual time ought to have suited these species well (Sections 7.1.10 and 7.1.11).

3. Method Description

3.1 Quantification by weight and number

In order to present a full picture of the animal bone material from the Eastern Trench quantitative estimations of identified species are given both as weight (g) and as number of fragments (n). When required they are also given together with the percentage of both figures, calculated from the total identified material. This is done to pin-point sources of error and avoid incorrect conclusions since neither the weight nor the number of fragments alone give a fair representation of the numerical relationships between the identified species. If only *the weight* is given obvious errors arise immediately since, for instance, a humerus specimen from cattle weighs in general more than the same element from pig or pine marten. Furthermore, various weighing methods for quantifying the number of animals butchered at a site (for example Uerpman 1973) by multiplying the weight of different species by a constant are primarily based on the number of fragments identified to species. The weight of the fragments are also dependent on the condition of the deposit due to sedimentary factors, which can vary considerable both at an inter-site and at an intra-site level (Noe-Nygaard 1977, p 232–233). In addition the weight varies according to age, sex and plane of nutrition of the animals involved. Noe-Nygaard (1977) considers this method unreliable and suggests that this methodological approach should be abandoned at least for inter-site comparisons, while Clason (1974) and Sjøvold (1976) for instance prefer this approach. The weighing method has been critically evaluated (Casteel 1978).

The number of fragments depend on the degree of fragmentation of the bone material. The fragment method is influenced by several factors including the age and size of the animals, the inherent structure of bone tissue in relation to species and bone elements influencing differential fragmentation in various deposits.

There are also the differences in the number of skeletal elements per species to take into account, as well as the presence of complete skeletons, butchering and fracturing techniques. Many and various taphonomic processes, dynamic forces, are thus operating from man's contact with the living animal to excavation and collection. As regards the bone material from the pile dwelling, it is the final result of processes actively working during several thousand years.

Sjøvold maintains (1976, p 345) that the number of identified fragments can be biased depending on the chances of reconstructing larger bone parts from smaller pieces and of the skill of the osteologist. If the osteologist manages to identify several small pieces of the same bone, then this can clearly influence the relative number of identified fragments. The relative weight, however, does not need to be changed in the same way, since one needs to identify many small fragments in order to alter significantly the relative weight of one species. Chaplin (1971, p 67) considered the fragment method not suitable for inter-site comparisons, while Noe-Nygaard (1977, p 231–235) for example used it for a comparison between the two sites, Star Carr and Praestelyngen, on the basis of the estimated number

Table 9. Number of fragments (n) and weight (g) with the frequency given in % of identified species and animal groups.

Domestic animals	n	%	g	%
Cattle	1260	39.8	11121.7	74.8
Sheep	62	2.0	138.6	0.9
Dog	3	0.1	1.2	0.001
Pig	937	29.6	1506.4	10.1
Game				
Cervids	221	7.0	1566.7	10.5
Elk + Red deer	214		1512.8	
Roe deer	7		53.9	
Other wild mammals	238	7.5	451.6	3.0
Wolf	6		15.9	
Brown bear	4		333.6	
Badger	36		31.7	
Pine marten	115		39.5	
Lynx	2		4.5	
Wild cat	26		11.2	
Beaver	6		10.4	
Mountain hare	12		2.5	
Ground vole	22		3.3	
Field vole	8		1.1	
Common shrew	1		0.1	
Birds	17	0.5	7.0	0.05
Fish	430	13.6	72.2	0.5
Total	3168	100.0	14867.6	100.0

of fragments (EF) of red deer and the number of fragments (NF) of red deer found at the sites. The estimated number of fragments (EF) is based on an estimation of the number of fragments derived from one animal and subjected to a specific marrow fracturing pattern.

In addition the total number of fragments retrieved from an excavation is depending on the excavation techniques. In cases of careful excavation, sediment sampling and water-sieving, as in the excavation of the Eastern Trench, even very small fragments can be retrieved.

In the main both the weight and the number of fragments can be useful, depending on which way they are used to measure the quantitative composition of the fauna. Differences in estimations, when using both the number of fragments and the weight, are illustrated in Table 9 and Fig. 9.

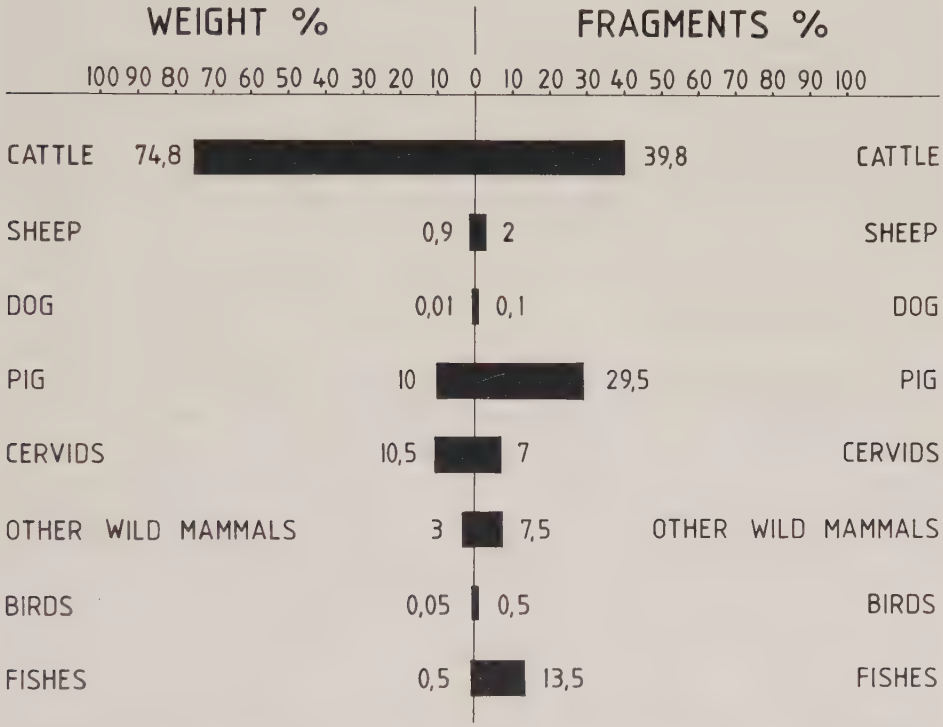
WEIGHT %
FRAGMENTS %
100 90 80 70 60 50 40 30 20 10 0 10 20 30 40 50 60 70 80 90 100
CATTLE 74,8 39,8 CATTLE
SHEEP 0,9 2 SHEEP
DOG 0,01 0,1 DOG
PIG 10 29,5 PIG
CERVIDS 10,5 7 CERVIDS
OTHER WILD MAMMALS 3 7,5 OTHER WILD MAMMALS
BIRDS 0,05 0,5 BIRDS
FISHES 0,5 13,5 FISHES

Fig. 9. Relative frequencies of the number of fragments (n) and weight (g) of DOMESTIC ANIMALS, PIG, CERVIDS, OTHER WILD GAME, BIRDS and FISHES. A graphic presentation of Table 9.

In the Eastern Trench bone material there are some skeletally very similar species, that is cattle, elk and red deer, and sheep and roe deer. To be able to identify also small and fragmentary bone elements from such animals with respect to particular species the fragment must have certain morphological criteria left intact, which are characteristic for the particular species and not for any other. If such criteria are missing then one gets fragments, which can only be identified as belonging to a group of closely related species within the same higher taxon (a so-called major taxonomic group in Table 7). In connection with

the quantification of the bone material an attempt has been made to allocate some of this 'grouped' material to particular species. The allocations has been made by using a statistical model for relative quantification (Chapter 5). The results of these statistical evaluations have been used in order to demonstrate the distributions of different bone elements of one species as well as the proportion of different species in relation to one another. The allocations have been used with respect to both the number of fragments and the weight.

In the case of carefully undertaken excavations it has been pointed out that the weight percentage of unidentified fragments to the total weight gives a better impression of their relative importance than does the number of fragments (Noe-Nygaard 1977, p 233). In the Eastern Trench the small unidentified fragments retrieved from the water-sieving constitute generally the main part of the whole number of unidentified fragments. The figures from the unburnt material can serve as an example (Tables 2 and 3). The total number of fragments from unburnt animal bone material is 19,940 pieces. The number unidentified is 16,774, or 84 %, a very high proportion. Considering weight, the total weight of unburnt animal bone material is 25,340 g. The weight of the unidentified pieces 9213.6 g corresponding to 36 %, a much smaller proportion. In conclusion, the figures show that the unidentified unburnt material consists of very small fragments which do not weigh much.

3.2 Age determination

The assessment of age at death for animal samples is an important and difficult task and a basic feature of archaeozoological work. Accurate estimations of age of domestic and wild animals can only be made if certain conditions are fulfilled. Well documented age characteristics and levels of nutrition ought to be known for the species or populations in question. Ideally, one needs access to most of the teeth and representive bones and most precise ageing can be obtained if the animal is not fully adult. Animal bone material from an excavation can hardly fulfill all these demands, since really accurate criteria are completely documented only for modern animals. Tooth development, growth and eruption, tooth attrition, bone development, growth and epiphyseal fusion can vary considerably between breeds, populations, and within single species, depending on aspects of nutrition, extent of mastication and diseases affecting young animals. These factors are hard to evaluate in an ancient bone material. In addition, it is only under rare and favourable circumstances that several representative bone elements can be identified as belonging to one and the same animal, especially when dealing with bone fragments, often food debris, from archaeological deposits. Fortunately, because they are food debris, many of them often originate from young animals, which at least simplifies the work (Silver 1963, p 283, Grant 1978, Watson 1978, van Wijngarden-Bakker 1980, p 88). When dealing with animal bones from graves it is more usual to retrieve bones from one individual. Unfortunately, humans often, through butchering and fracturing the bones for different purposes, render the age determination more difficult. Moreover,

there are remaining taphonomic processes which affect young bones more severely, since generally they are less resistant to decomposition than bones from adult animals.

Most methods for estimating the age of domestic and wild animals give an age range. Usually the length of time covered by each range is less for teeth than for epiphyseal fusion. It should be emphasized that different methods can produce different results. This has been demonstrated by comparing tooth eruption and wear stage with epiphyseal fusion data (for example Maltby 1982) and by using skull fragments to check tooth wear and eruption (Stampfli 1976). It has also been pointed out that among older animals of both bovids and cervids often the teeth in one half of a jaw may be more worn than the teeth in the other (Habermehl 1961, p 176). Generally it can be said that assessment of age at death of prehistoric animals ought to be undertaken with great caution and that information should be gathered from as many individual bone elements as possible (Grigson 1982a). It has been suggested that domestic animal remains from sites dated before selective breeding are similar in ageing to primitive, late maturing modern domestic animals of the same species. Teeth eruption and epiphyseal fusion are held to be slower in primitive domestic animals than in modern advanced varieties (Silver 1963). Concerning, however, pigs later studies have shown that tooth eruption in wild boar and domestic pig is probably less variable than has been thought. It means that data for slower-erupting modern pigs and wild boar probably are suitable for ageing pig remains from archaeological material (Bull & Payne 1982, p 65–70).

In wiew of these various ageing problems, information has in general been gathered from as many bone specimens as possible when estimating the age composition of the animals identified in the material from the Eastern Trench (Chapter 4). In order to estimate the age of the *bovids* mainly fusions of post-cranial epiphyses have been used and also the surface texture and appearance of the bone of one horn core (Habermehl 1961, Silver 1963, Armitage 1982). It was not possible to use jaws and teeth. There were no fragments of mandibles with teeth remaining and the permanent M_3 and the deciduous m_4, both easy to identify to body side, occurred just in isolated specimens. It should be noted that in general unfused elements from different age groups have been interpreted as being from animals younger than the upper limit of the given age range. Conversely the fused elements should be interpreted as being from animals older than the lower limit of the given age range. The accurate estimation of age of the *cervids* have in some cases been possible using the epiphyseal fusion of limb bones (Bosold 1981, p 101, Iregren 1975).

The estimation of age for *pig* are based on both fusion of post-cranial epiphyses, jaws and teeth. Bull & Payne (1982) emphasize that the timing of tooth eruption in wild boar and domestic pig probably is less variable than earlier suggested. There is less information available for the timing of epiphyseal fusion than for the tooth eruption. Authors rarely define what they consider the moment of fusion, if it is, for instance, the final closure of the gap along the closure line. However, in spite of limited informations, Bull & Payne (1982)

argue that the fusion may be later in wild boar than in modern pigs. According to available information 'later' fusion and eruption times have been used for estimating the age of pig remains from the Eastern Trench considering limb bones and deciduous teeth (Lesbre 1897/8, Gabriel 1934, Habermehl 1961, Silver 1963). In the case of the age of eruption of permanent teeth, average values for wild boar have been used (Maschke 1967).

Epiphyseal fusion has also been used to closer estimate the age of the *dog* (Habermehl 1961, Silver 1963).

For remaining mammals occurring in the material the assessment of age for each identified species is discussed more in detail in Sections 4.1.7–4.1.18. It should be noted that in general very little is known about the time of epiphyseal fusion and tooth eruption among wild mammals compared to domestic ones.

Concerning the bird remains they do not show any distinct criteria of coming from young birds. As for the fish bones no assessments of age have been made.

3.3 Sex determination

It has only been possible to carry out more positive assessment of sex for some of the identified species. In general three methods are available: 1) secondary sexual criteria, 2) metric sex differences and 3) morphological criteria. Results from the metrical discrimination of the sexes should be interpreted with caution, since they are biased by age and environmental conditions (level of nutrition, growth rate and castration).

In identifying the sexes of *cattle,* one horn core and the distal width of metacarpals have been used. In general male cattle are larger than females. They have more strongly developed muscle attachments, heavier and larger bones, especially limb bones. Sexual dimorphism is, however, more pronounced in the front part of the body, due to the greater size and weight of skull and horn cores among bulls. In their determination of sex from the horn core Armitage & Clutton-Brock (1976) use the minimum diameter at the base times one hundred, divided by the maximum diameter at the base as a sex determining index. Below about 70 mm the index seems to indicate bull and above about 85 mm it seems to indicate cow. In the intermediate space the index gives no clue as to sex. In the present sex assessment the cross-section of the horn core base and to a certain extent an estimation of its prominence from the skull were used. Armitage & Clutton-Brock (1976) argue in their horn core study that the results reflect true sexual dimorphism, since the characters used for classification of cattle horn cores from archaeological sites remain unchanged throughout all periods. On the other hand it is pointed out that sexual variations can be found in local populations and that criteria useful for one type of cattle in one period may not be applicable to other periods with different types. It has been argued that there is a marked sexual dimorphism which separates bulls from cows in the distal breadth of the metacarpals (for example Grigson 1982a). Using the cattle sample from the Danish Funnel Necked Beaker settlement at Troldebjerg, Higham & Message (1969) have pointed out variation of the maximum distal width of the

metacarpals and, by using statistical methods, found a significant range of variation for males and females. Their results have been used to estimate the sex of cattle bones from the Eastern Trench.

Among the cattle remains it has not been possible to distinguish between bulls and oxen. In view of this question experiments on modern Swedish red and white cattle demonstrate that castration of young bulls severely affects the skeleton of the individuals (Brännäng 1971). In general the following changes have been noted. As regards the axial skeleton the bones are reduced in length, resulting in a shorter neck and body length among steers than among bulls. On the other hand the limb bones below humerus and femur increase in length, resulting in taller steers than bulls. As regards the foot bones, i.e. metapodials and phalanges, their longitudinal growth becomes greater the earlier the castration has taken place and the diaphyses of the metapodials become more slenderly built. The result has a distinct effect on the withers height. There are, however, other changes. The appearance of the horn cores are for instance affected (Armitage & Clutton-Brock 1976, p 332, Figs. 5, 6). Other investigations have been done in order to try to distinguish bulls from castrates by measuring the distal breadth of the metapodials (for example Fock 1966, Higham & Message 1969). It is further thought that the bones of steers in general mature later, that is the epiphyses fuse later, and Brännäng (1971, p 77–78) clearly stresses that the increased length growth of the distal limb bones is directly due to a delayed ossification, that is a delayed epiphyseal fusion. A late epiphyseal fusion has earlier been noticed among proximal epiphyses of tibiae from castrated cattle (Figdor 1927).

In estimating the division of the sexes among *red deer* antler fragments and measurements of phalanges have been used. In the assessment age, size and morphological characteristics of various fragments have also been considered. Among red deer there is a considerable size difference between the males, stags, and females, hinds. Throughout its history the red deer seems to have varied in size at different times and places. The size is determined by sex but also by nutrition depending on habitat. Evolutionary factors have also been discussed behind size changes. However, a general decrease in size from prehistoric times up to recent time has taken place. This should be taken into account when estimating sex in archaeological material (Ahlén 1965 and there cited litt., Bosold 1978, Noddle 1982). Measurements of both phalanx I and phalanx II have been used. As a rule they are longer and heavier by stags but there are overlapping values (Bosold 1978, p 116, Table 2). A skull fragment with remaining part of the burr and morphological characteristics of a broken mandible (Boessneck 1973) have been used to identify the sex of *one roe deer.*

Assessment of sex for *pig* has been made on the differential morphology of the lower canines of boar and sow. The age, size, morphology and measurements of various other bone elements have also been taken into consideration. It has been argued that male and female pigs, unlike species such as cattle, generally do not differ enough in mature body size to make it possible to identify castrated forms through bone measurements. Secondary sex differences affected by castration, such as horn cores, are absent among pigs. So far there seems to be no method

available to demonstrate that castration of male pigs took place in prehistoric times (Hammond et al. 1971, van Wijngarden-Bakker 1980, p 162). Moreover it has been shown that the limb bones show no size differences between male and female pigs (Becker 1980, p 30–31, 71).

Furthermore, in addition to the sex determinations mentioned above, attempts have sometimes been made to try to identify the sexes of other species identified in the material by using age, size, morphology and measurements of bones and teeth and by comparing with other already sexed materials. All assessments of sex of identified species are discussed more in detail in Chapter 4. Metric sex differences are also used in connection with testing the Alvastra material against others (Chapter 7).

3.4 Withers height estimation and skeletal measurements

In the bone material from the Eastern Trench withers height could only be calculated from one ulna of a *wild boar* and one talus of a *wild boar or domestic pig.* Withers height calculated from the tali of pig (Table 66) is used in connection with the testing of this against other material (Section 7.1.6). Moreover there will be calculations from metapodials of *cattle* retrieved from earlier excavations of the pile dwelling to test against other samples (Section 7.1.1, Tables 47 and 48). In the bone material there is an intact ulna identified as *brown bear,* but I have not been able to find any published formula connecting the withers height of brown bear with the maximum length of ulna.

The total number of measurements which it has been possible to calculate from jaws, teeth and other skeletal elements belonging to the different identified species in the material are given. In addition to these measurements of specimens from the Eastern Trench, comparative data are given from unpublished analyses of bone material from Alvastra pile dwelling and other prehistoric as well as Middle Age and modern series (Chapter 7, Tables 33–75). Many dimensions are discussed further in connection with the results of age and sex determinations and estimations of the number of individuals (Chapter 4), the discussion of life and economy and in comparing the material with other samples (Chapter 7).

As regards the measurements a numbered list has been made for the Alvastra bone material and for all bone materials used in Tables 33–75 for comparison with the pile dwelling material. Unless otherwise stated the definitions and abbreviations of the measurements of cranial and postcranial skeletal elements in the following chapters are those defined by von den Driesch (1976). The measurements of teeth and bone elements are, as a rule, given in mm. The measuring error is estimated to one tenth of a mm.

3.5 Estimation of numbers of individuals

The bone material has been considered as one spatial unit when estimating the numbers of individuals, since the area is limited, about 15 m^2, and fragments have been found which fitted together coming from different squares and levels.

The minimum number of individuals (MNI) method (White 1953) is certainly the most commonly used of all quantifying methods. The simple 'traditional' method uses counts of the most abundantly represented bone element or part of a bone element of each species considering age and bone side, if the bone is bilateral. Elaborations of this 'traditional' MNI count exist, for instance, Grand Minimum Total (GMT), which also considers bone size and morphology (Chaplin 1971, p 70–75). GMT is calculated by pairing similar bones/parts of bones suggesting that they come from the same individual. The number of pairs is then added to the single unpaired bones/parts of bones. The GMT will give a somewhat higher value than the MNI. Horton (1984) uses the terminology actual number of individuals instead of GMT.

To begin with a more 'traditional' estimation of the minimum number of individuals has been used on mammals in this material. The method is here called Extended MNI or EMNI. This estimation is not just based, as in GMT, on the most frequent bone element/part of a bone element per species taking into account body side, age, size and if possible sex. In the present case, when the identified material per species has been surveyed, as many different skeletal fragments as possible are used in the estimations (Boessneck et al. 1971, p 8). This procedure makes it possible not only to see how different bone elements are distributed according to age groups and species, but also to use the fact that the point of time of epiphyseal fusion may differ considerably between different bone elements and also between different parts of the same bone from one species. Furthermore, by using measurements and morphological characteristics, even fragments have been identified as coming from different individuals. Hence information is gathered from as many individual bone elements as possible. By this careful analysis of the mammal remains it is obvious that one specific type of bone element (even if body side, age etc. are taken into account) may not be sufficient for estimating the minimum number of individuals for a species. Thus individuals may be added, which are represented by their own specific fragments, which morphologically and by size can not be allocated to fragments already identified as belonging to an individual. Some EMNI estimations have also been based on teeth, their eruption and attrition. By considering all suitable types of skeletal elements a better basis is given compared to a 'traditional' MNI estimation. The possibility of missing an individual of a species which is represented by only one fragment is thus diminished. The results of the EMNI estimations are shown in Chapter 4 and Tables 10–18.

There are, however, various reasons for considering the results of this estimation with a certain caution, since the basis for the estimations is just a sample from the total large bone collection from Alvastra pile dwelling. This means that the bone material from the Eastern Trench does not need to be representative, since there may be a heterogeneous distribution of different species over the total area of the pile dwelling. One animal may also have been butchered and distributed among larger areas. Furthermore, the statistical deviation or standard deviation is large for small samples. In general a MNI estimation gives only the minimum guaranteed number of individuals of a species represented in material. In

order to provide a correct estimate of the real number of different animals occurring in a bone series the MNI method requires that exactly the same bone element or part bone element is found from each single individual and that it can be identified. It is easy to demonstrate the larger the material and the longer the period of deposition, the greater the probability that this bone element or part bone element is missing from one or several individuals. Because of these and other reasons the MNI methods are likely to underestimate the original number of individuals per species, especially as regards old and large materials.

When studying a small sample, it is here argued that a careful approach to the estimation of the MNI, such as the EMNI, including various skeletal parts, has somewhat diminished such underestimation. Naturally an individual may be represented by a bone which has been fractured in such a way that one part has ended up in the trench, the other outside. This other part of the bone may be included in another MNI estimation. On the other hand, another individual might be represented only by unidentified pieces or fragments of ribs, for instance, which are not used in this EMNI estimation, which means that the individual is not included at all. These two phenomena may tend to cancel each other out. Of course it is possible that the bone material from the Eastern Trench represents a larger numbers of individuals than the EMNI results show. It is, however, here suggested that the EMNI shows, at least for the majority of the species the relative proportion among these and the results generally agree with the proportions of species when quantifying in number and weight (Table 6). In this context it can be noted that White (1952, 1953), who seems to be the 'father' of the MNI method, only used MNI in an attempt to assess the relative contribution of different species to the diet of the people living in a site.

Several authors have pointed out the limitations of the 'traditional' MNI method and proposed other methods of estimating the number of individuals, some trying to give a more reliable expression of the minimum number of individuals present, and some being more ambitious than others (Krantz 1968, Gejvall 1969, Grayson 1973, 1978, 1979, Perkins 1973, Uerpmann 1973, Lepiksaar 1974, 1982, Casteel 1977, Noe-Nygaard 1977, Poplin 1978/79, Lie 1980, 1983, Aaris-Sørensen 1981, Gilbert, Singer & Perkins 1981, Gilbert & Singer 1982, Fieller & Turner 1982, Wild & Nichol 1983, Ducos 1984). In order to compare methods and results, estimations have been carried out on the animal bone material from the Eastern Trench using a choice of alternative methods from the works of Krantz (1968), Casteel (1977), Poplin (1978/79), Lie (1980).

Casteel's estimations are based upon a significant correlation between the ratio MNI/E and E, where E represents the number of identified elements per species or taxon occurring in the material. Casteel argues that, what is really sought, is the relationship between MNI and E. This relationship is examined for two ranges: 1) small faunal collections ($E \leqslant 1000$) and 2) large faunal collections ($E \geqslant 1000$).

For small samples the relationship is described by the following formula:

$$\text{MNI} = 0.77\,(E)^{0.52}$$

For large samples the following formula describes the relationship:

$$\text{MNI} = 5.56 + 0.0225\,(E)$$

It is further argued, since MNI is a function of the number of identified specimens for a species/taxon, that field techniques in connection with recovery of the remains are of great importance. Significant biases may result in errors in MNI values and render a comparison between sites more difficult (Casteel 1977, p 146–147). When comparing the 'traditional' MNI with Casteel's MNI his method gives in general a far larger number of individuals per species. Casteel's method has been used in this study to calculate the number of individuals of mammals and fish. The results of these calculations are given and discussed in more detail in Sections 4.1.1–4.1.18, 4.3 and Chapter 8.

Poplin's method aims at estimating the original number of individuals (N) of species which have contributed to the faunal remains. His estimations are based on the number of bone elements in question identified as to side of body, and the number of probable pairs which some of them are supposed to establish. The calculations are made according to the following formula:

$$\text{N} = (A_L + B_L)(A_R + B_R)/P \cdot$$

Here A designates bone specimens considered to be paris, B bone specimens where it is possible to decide on body side but without making pairs: L means left and R means right. Hence in this formula $A_L + B_L$ are the number of left bone elements fit for use, $A_R + B_R$ are the number of right bone elements fit for use and P are the number of identified pairs of the bone elements. It is further argued, since the limit between useful specimens is not always clear-cut, that it may be advisable to make two selections, one generous and one strict and then use a mean value. Considering the pairing of the bone elements it may also be advisable to give them a minimum, a maximum and an average value (Poplin 1978/79, p 155). Poplin's method has in this study been applied to proximal fragments of radii from cattle. The results of the calculations are given and discussed in Section 4.1.1 and Chapter 8.

Krantz's method also aims at estimating the original number of individuals deposited in a faunal assemblage. The method starts from the fact that, in the vertebrate skeleton, many bones occur on the left and right sides and, moreover, that they can be paired according to the individual. Krantz suggests that the proportion of pairs to the identified number of left (or right) bone specimens equals the proportion of left (or right) bone specimens to the original number of individuals deposited in the assemblage. Krantz's study is based on the examination of mandibular halves of herbivores, which is said to give the best result. He has selected the mandible becuse "it is 1) a very hard bone with a high survival rate, 2) one of the best diagnostic bones for identifying species and 3) about the easiest of all paired bones to match according to individual". Krantz maintains

that it is not usually the case that the numbers of left and right bones are exactly the same. In case they are not he suggests the following averaging formula to be used:

$$N = \frac{L^2 + R^2}{2P}$$

which for $L = R$ reduces to:

$$N = \frac{L^2}{P} = \frac{R^2}{P}$$

Here N is the number of animals in the original population, L is the total number of left bone elements found, R is the total number of right bone elements found and P is the number of pairs established (Krantz 1968).

It should be noted that Fieller & Turner (1982) use the same method as Poplin (1978/79), that is,

$$N = \frac{LR}{P}$$

to produce a simplified version of Krantz's formula.

In the material being studied Krantz's formula has been used on the proximal fragments of radii belonging to cattle. The results of the calculations will be presented and discussed in Section 4.1.1 and Chapter 8.

Lie's method aims at finding the lowest value forming the minimum number of individuals of a species, which have been present in order to produce the numbers of bone elements in question. Lie uses the distribution of identified left and right specimens of a certain bone element from an animal, assuming that it is a random sample and that right *(R)* and left *(L)* bones have an equal chance of surviving and being excavated and that, initially, the same number of bones from both sides have been deposited. He then calculates the MNI by choosing between two formulae, depending on whether the number of individuals is likely to exceed or fall below the size of the sample that is $L + R$. The probability that the calculation value is the lowest possible for the MNI has a 95 % confidence interval (Lie 1980). In order to apply Lie's method to the Eastern Trench bone sample, consisting of the proximal fragments of radii from cattle, a small computer program was developed. The calculations are presented and discussed in Section 4.1.1 and Chapter 8.

The four related methods considered above were used since they seemed applicable to the material from the Eastern Trench, albeit with the reservation, already pointed out, that it is a small sample. There are of course other interesting studies which investigate matters of faunal quantification. For instance Gilbert, Singer & Perkins (1981) who by computer simulations show different degrees of accuracy and quality of three bone counting methods: 1) the total number of fragments (TNF), 2) the minimum number of individuals (MNI) and

3) the relative frequency (RF). It is suggested that RF calculations provide the best accuracy and MNI calculations the worst. However it is pointed out that, if the calculations are based on bone material where the proportion of species is skewed (unbalanced), the RF method has less accuracy and further, if the TNF method is corrected for skeletal complexity, it would likely become the best estimating method. It is also pointed out that depositional biases are not included in these simulations. The RF method is a modified form of the TNF method which suggests that each fragment comes from a different individual assuming low faunal recovery conditions (Perkins 1973). Perkins's RF method is based on 1) establishing the number of diagnostic bone elements of the whole animal population involved in the estimation, 2) adding up the number of such specimens from each species, 3) dividing the number of specimens (C) by the number of diagnostic elements (D) to calculate the frequency (F) of species, 4) summing up the frequencies ($\sum F$) and 5) calculating the relative frequency (RF) for each species by dividing its frequency (F) by the sum of frequencies ($\sum F$) (Perkins 1973). It has been criticized that neither TNF nor RF discriminate between bone elements from the same and those from different skeletons (Grayson 1979). Since the bone material from the Eastern Trench represents 18 species of mammals and since several of them, even skeletally similar animals, are represented by rather few bone elements it is argued that it was neither adequate nor possible to try to make an RF estimation of the material.

Gilbert & Singer (1982) present a very interesting theoretical study of taphonomic problems creating depositional biases and propose mathematical decay models in quantification. However, no method is given of how to calculate the coefficient of taphonomic effects which is the coefficient used in the formula. Because of this it was unfortunately not possible to use the calculations on this bone material.

All estimations of the numbers of individuals for the different species of mammals are presented and discussed, species by species, in Sections 4.1.1–4.1.18. As to the estimations of numbers of individuals for the different species of bird and fish the results are given in Sections 4.2 and 4.3.

4. The results of age and sex determinations and estimations of the number of individuals

In the following Sections (4.1.1–4.1.18) the results of the different methods are given and discussed, species by species, for the mammals. After the name of the species the number of individuals, given by different methods, is shown. Cattle (Domestic *Bos)* is the only species, which is represented by enough suitable fragments to make it possible to use all five methods of estimating the number of individuals. For all species which are represented by two or more individuals in the EMNI estimation, tables have been assembled (Tables 10–18). These tables show the bone elements, which were used in the estimation, taking into account number, body side, age, measurements and if possible sex of the different individuals. The diversity is in general great among all mammals occurring in the material (Fig. 10). This means that the number of individuals of each species is relatively small but that the number of species on the other side is relatively large.

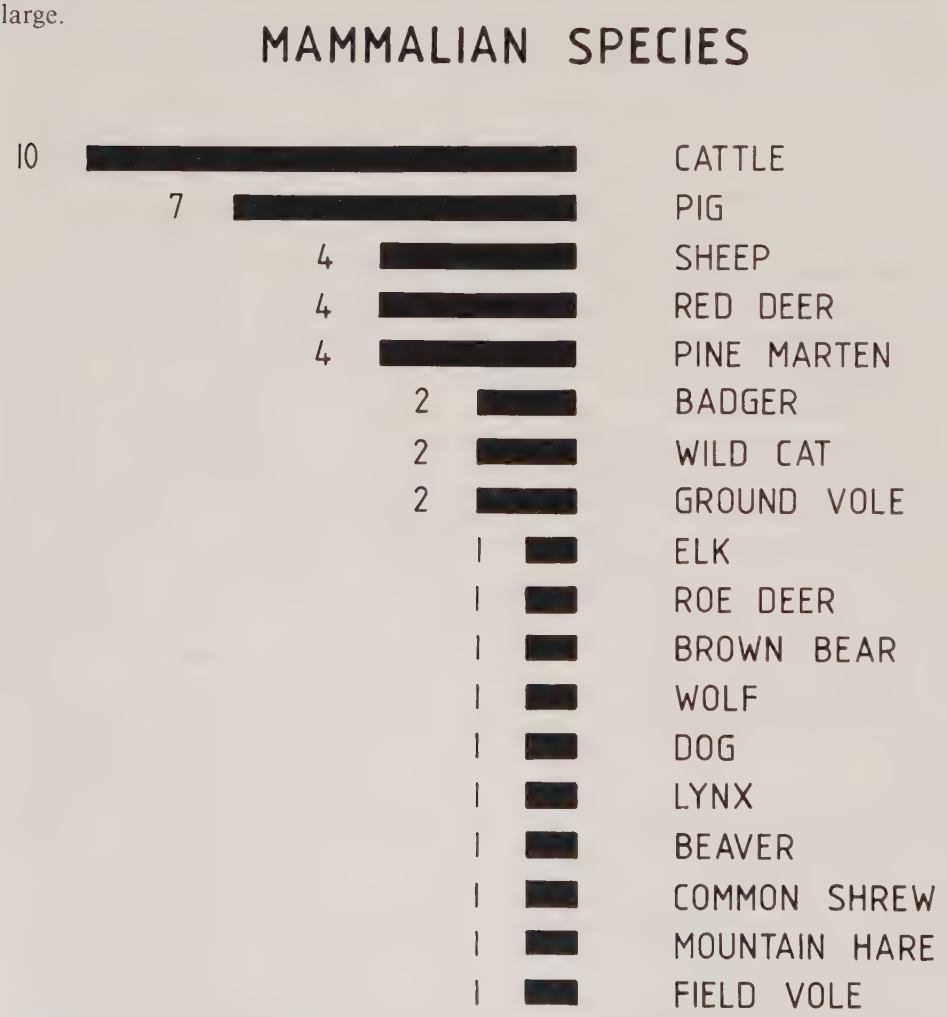

Fig. 10. Diversity of MAMMALIAN SPECIES based on the EMNI estimation.

Since the bird bones are few (Table 19) the results are presented and discussed for all bird species together in Section 4.2. The number of different bone elements among identified fish species is given (Table 20). The result of the estimation of the number of individuals of different fishes is presented and discussed for all species in Section 4.3. The latin names of all species are given in brackets. The nomenclature is given according to Bohlken (1961), Siivonen (1976) for mammals, Bruun & Singer (1975) for birds and Muus & Dahlström (1981) for fishes. Unless otherwise stated the measurements are given according to von den Driesch (1976). The results of all different methods used to estimate and calculate the numbers of individuals are presented in Table 21 (Section 4.3.).

4.1 Mammals

4.1.1 Cattle (Bos primigenius f. taurus); 10 individuals (the EMNI estimation)
34 individuals (Casteel's method)
10, 13 or 20 individuals (Poplin's method)
11, 15 or 22 individuals (Krantz's method)
8 and 6 individuals (Lie's method)

13 proximal fragments of radii, 8 from the left and 5 from the right body side, are the basis of most of the estimations of the number of individuals. This is the bone element, which is most frequent among the bone fragments identified to body side and suitable for MNI etc. estimations. Hence the result of a simple 'traditional' MNI is 8 individuals. But this part of the bone has an early fusion and because of this is less convenient as a basis for a more differentiated age determination. However several other bone elements have been used regarding the age determination (Table 10). The bone elements used in the EMNI have not only been compared as to age but also morphologically. For comparison of size and also sex, different measurements are taken (Table 10). Except measurements given according to von den Driesch (1976), the following are given:

Radius prox Gbdv = Maximum breadth of the proximal end, medial side, taken in the dorsal/volar direction.
Radius dist Gbdv = Maximum breadth of the distal end, medial side, taken in the dorsal/volar direction.

The appearance of the only nearly whole horn core in the material suggests a stage of bone growth between age classes 2 and 3, that is, subadult to young adult (Armitage 1982, p 37–42). Thus the horn core may have belonged to either Individual 6, 7 or 8, perhaps most probably Individual 6. Since there are some thoracic and lumbar vertebral bodies with fused body epiphyses there are likely to be individuals older than 6–7 years among the adult animals (Grigson 1982a, p 15). Considering the rather oval cross-section of the horn core, 66.6 mm (Section 7.1.1, Table 33) and the fact that it seems to have extended straight out from the skull, could indicate that it has belonged to a bull. Further sex determinations have been suggested using the measurements of two distal metacarpals.

According to Higham & Message (1969, p 316) the range of variation for females is 53.0–63.5 mm and for males 64.0–73.0 mm. Taking these values into account the metacarpals (both from the right side), which measure 64.9 mm and 67.1 mm respectively, may have belonged to males.

Taking all criteria mentioned above into consideration, the EMNI estimation suggests 10 individuals. It is likely that four of them has been more than 3.5 years old (Individuals 1–4); one more than 2 years old (Individual 5); one more than one year but less than 4 years (Individual 6); one more than one year but less than 2.5 years (Individual 7); one less than 2.5 years (Individual 8); one less than 1.5 years (Individual 9) and finally one about a year old (Individual 10). Individuals 1, 5 and possibly 6 may be bulls (Table 10). On the basis of the measurements no females have been identified. The presence of cows in the material from the Eastern Trench is, however, not excluded. Measurements of, for instance, proximal radius elements and in general size and morphology of different bone types seem to point at variation in size among the mature individuals, possibly indicating remains of both males and females. Moreover there seem to be remains of animals older than 6–7 years. This could indicate cows kept for milk production and reproductive purpose.

The material being studied provided no opportunity to estimate the withers height of the adult individuals. However, to make it possible to get an idea of the withers height among the cattle present in bone material from the pile dwelling, measurements of both metacarpals and metatarsals (Table 43) given in earlier, unpublished, analyses of excavated bone material from the site were used in an estimation. The available data allow the statement that the cattle may have attained, at maturity, a withers height of between 114 and 140 cm suggesting a wide range of height (Tables 47 and 48). It should be emphasized that using another method, for instance Matolsci's (1970/71) in calculating withers height, the results are not the same and give values of between 124 and 140 cm (Tables 47 and 48). Sexual dimorphism, growth pattern and also plane of nutrition are three factors which influence withers height in cattle. These factors are subject to human forces and also have an interrelationship (van Wijngarden-Bakker 1980, p 115). Taking into account these methodological problems, the figures of withers height among cattle, identified in bone materials from the pile dwelling, are given disregarding the sexual influence.

Casteel's method has been applied to all fragments identified to cattle, 1260 pieces, and his formula for large samples has been used. The calculations gave as a result 34 individuals, a considerably higher value than the more 'traditional' type of estimation, the EMNI.

Poplin's method was applied to 8 proximal parts of radii from the left side and 5 from the right side. All the 13 bone elements were strictly identified as to side. The number of pairs which have been used are 2, 3 and 4. Using 2 pairs in the calculations the result was 20 individuals, using 3 pairs 13 individuals and using a maximum value of 4 pairs 10 individuals. To try to pair bone elements is a difficult task, especially when they are not complete and when, obviously, right and left bones of an animal need not be exactly alike. Therefore the results of a

Table 10. **EMNI** estimation for **Cattle** on the following bones: Radius (Ra), Ulna (Ul), Metacarpal (Mc), Tibia (Ti), Metatarsal (Mt), Phalanx I and II (Phal), Vertebrae sacrales (Ve s); proximal (p), distal (d), diaphysis (dia), epiphysis (epi), juvenile (j), left (L), right (R), year (y), Measurements in mm.

Cattle

		Ind. 1	Ind. 2	Ind. 3	Ind. 4	Ind. 5	Ind. 6	Ind. 7	Ind. 8	Ind. 9	Ind. 10
Ra p	L	–	1	1	1	1	1	1	1	1	–
	R	1 >1y	– >1y	1 >1y	1 >1y	1 >1y	– >1y	1 >1y	–	–	–
Ra d	L	–	–	–	1	–	1	–	–	–	–
	R	–	–	–	1 >3.5y	–	– <4y	–	–	–	–
UL p	L	–	1	1	1	1	1	1	–	–	–
	R	–	– >3.5y	–	1 >3.5	–	–	1	–	–	–
Ra+Ul	L	–	–	1	–	–	–	2	–	–	–
	R	1 >3.5y	–	1 >3.5y	–	–	–	2 <4y	–	–	–
Mc d	L	–	–	–	1	1	–	–	1	1	–
	R	1 >2y	1 >2y	1 >2y	– >2y	1 >2y	–	–	– <2.5y	– <2.5y	–
Ti p	L	–	–	–	–	–	2	–	–	–	–
	R	–	–	–	–	–	– <4y	–	–	–	–
Ti d	L	–	–	1	1	–	–	–	–	–	–
	R	–	1 >2y	1 >2y	1 >2y	–	–	1 <2.5y	–	–	–
Mt d	L	–	–	–	–	1	–	2	–	–	–
	R	–	–	1 >2y	–	– >2y	–	2 <3y	–	–	–
MT dia	L	–	–	–	–	–	–	–	–	–	–
	R	–	–	–	–	–	–	–	1 <3y	1 <3y	–
Phal		–	–	–	–	–	–	–	–	2 <1.5y	–
Ve s		–	–	–	–	–	–	–	–	–	2 ≈1y

Ra	PGbvd	45.0R	38.2L	35.6R	34.4R	39.6R	39.2L	33.9R	–	–	–
	DGbvd	–	–	–	32.3R	–	35.7L	–	–	–	–
Ul	DPA	–	59.5L	–	55.6L	59.5L	–	–	–	–	–
Ra+Ul	Bd	–	–	65.9L	–	–	–	67.6Lj	–	–	–
		–	–	66.0R	–	–	–	67.4Rj	–	–	–
MC	Bd	67.1R	–	–	–	64.9R	–	–	–	–	–
Ti	Bp	–	–	–	–	–	94.9Lj	–	–	–	–
Ti –	Bd	–	63.2R	59.0L	58.3R	–	–	55.8Rj (unfused epi)			
Mt	Bd	–	–	54.9R	–	58.8R	–	–	–	–	–
Age (year)		>3.5	>3.5	>3.5	>3.5	>2	>1	>1	<2.5	<1.5	≈1
Sex		♂				♂	♂ ?				

'pairing' may often be regarded as uncertain. According to Poplin (1978/79, p 155) a minimum, a maximum and an average value of pairs of radii were used in order to compare his N method with the EMNI estimation. The selected values of pairs in the material being studied were thus 2, 4 and 3. In this case the possibility of 4 pairs is supported by the fact that there are also 4 proximal specimens of ulna, each apparently being connected with the relevant proximal part of radius (Table 10, Individual 2, 4, 5, 7). Using 4 pairs gave the same result as the EMNI method, 10 individuals.

Krantz's method was also applied to the 8 proximal elements of radii from the left side and the 5 from the right side. Since the radius cannot be paired as definitely as Krantz suggests for mandibular halves, the number of pairs has been given a minimum (2), a maximum (4) and an average (3) value. Using these numbers of pairs the calculations estimate the original number of individuals as either 22, 11 or 15 animals for respectively 2, 4 and 3 pairs. This result is not too different from that of Poplin.

Lie's method was applied on the 13 specimens of radii, 8 from the left and 5 from the right side and also on 8 proximal specimens of ulnae, 6 from the left and 2 from the right side. The calculations gave the same results as a simple 'traditio-

nal' MNI estimation, 8 respectively 6 individuals. When looking into this matter, it appears that in order to get a higher figure from Lie's method than is given by the 'traditional' MNI, the proportion of left *(L)* and right *(R)* fragments has to be more skewed the smaller the sample size *(L + R)* is. For example 2 or 5 bone elements from one side need at least 7 respectively 10 from the other side to get a higher figure than is given by the 'traditional' MNI estimation. In other words, in order to get a result suggesting a higher number of individuals when applying Lie's method rather than the MNI method, the difference between the number of left and right bone fragments needs to be larger than 4 to 5. It should be noted that the number 4 is only applicable when there are *no* fragments identified from the other side. This means that Lie's method does not seem to give values different from the 'traditional' MNI method for small samples, which are not skewed enough, as for instance in this case.

The different methods, which have been used to estimate the number of individuals for cattle and in the following pages also for other species identified in the bone material from the Eastern Trench, will be further discussed in Chapter 8.

4.1.2 Sheep (Ovis ammon f. aries); 4 individuals (the EMNI estimation)
7 individuals (Casteel's method)

Four whole or fragments of one of the carpal bones, *os carpi 2 + 3,* all from the right side are the basis of the EMNI estimation. This is the most frequent bone element decided as to side. Since it has no epiphyses it is not suitable for a more accurate age determination. Therefore other bone specimens have been used considering ageing in connection with the EMNI estimation (Table 11). The specimens used in the EMNI have also been compared morphologically and as to size. Taking all criteria into consideration the result of the EMNI suggests 4 individuals. It is likely that one has been more than 3 years old (Individual 1) and one more than 2.5 years old (Individual 2). Hence they are probably both skeletally adults. The remaining two individuals could not be aged. Since there

Table 11. **EMNI** estimation for **Sheep** on the following bones: Os carpi 2+3, Femur, Tibia, Tuber calcanei; proximal (prox), distal (dist), left (L), right (R).

Sheep

		Ind. 1	**Ind. 2**	**Ind. 3**	**Ind. 4**
Os carpi 2+3	L	–	–	–	–
	R	1	1	1	1
Femur prox	L	–	1	–	–
	R	–	– >2.5 years	–	–
Tibia prox	L	1	1	–	–
	R	>3 years	–	–	–
Tibia dist	L	–	1	–	–
	R	–	– >1.5 years	–	–
Tuber calcanei		–	1 >2.5 years	–	–
Age		>3 years	>2.5 years		

are no fragments identified as goat and in order to use the phalanges suitable for ageing, but only identified as sheep or goat, an EMNI estimation has been made for the category, *'sheep/goat'* (Table 12). The result suggests 2 individuals, one older than 13 months and the other younger than 16 months. In Section 5.5 it will be demonstrated that only 0–4 fragments (0–7 %) of the bone elements identified as sheep or goat can possibly be allocated to goat and that 93–100 % of the specimens can be allocated to sheep. This should mean that probably at least one of the sheep, for instance Individual 3 or 4, has been less than 16 month old.

Table 12. **EMNI** estimation for **Sheep/Goat** on the following bones: Tibia, Phalanx I, Phalanx II; proximal (prox), left (L), right (R).

Sheep/Goat

		Ind. 1	**Ind. 2**
Tibia prox	L	1	1
	R	–	–
Phalanx I		1 > 13 months	–
Phalanx II		–	1 < 16 months
Age		> 13 months	< 16 months

Casteel's method has been applied to all 62 fragments identified as sheep, and his formula for small samples has been used. The calculations gave an estimate of 7 individuals, a higher value than the more 'traditional' EMNI estimation.

4.1.3 Elk (Alces alces); 1 individual (the EMNI estimation)
4 individuals (Casteel's method)

There are at least remains of one individual in the material. Using a distal unfused specimen of tibia, an unfused proximal epiphysis also of tibia and a distal unfused epiphysis of radius + ulna for an assessment of the age, the individual is a calf possibly less than 2 years old (Iregren 1975, p 375, Lepiksaar 1983, p 161). Casteel's method was used on all 21 fragments identified as elk.

Applying his formula for small samples the calculations gave an estimate of 4 individuals, a higher value than the EMNI estimation.

4.1.4 Red deer (Cervus elaphus); 4 individuals (the EMNI estimation)
12 individuals (Casteel's method)

Specimens of the metacarpals, metatarsals and the phalanges are the basis of the assessments of age (Bosold 1967, p 101). Also specimens of radius, ulna and tibia have been used for ageing. It is argued (Iregren 1975, p 376) that the epiphyseal fusion in elk and other deer may be in close agreement. Sex determinations are suggested based on the measurements of phalanges (Bosold 1967, Table 2, p 116) and are shown in Section 7.1.4, Table 58. All measurements of phalanges suitable for measuring are given in Table 57. Considering both juvenile and adult specimens of limb bones and phalanges morphologically and as to size and

measurements, they are all included in the sex determination. There are also fragments of antler in the material. The result suggests that there are remains of one or maybe two males and possibly a hind in the material. Taking all criteria into consideration the EMNI estimation gives a result of 4 individuals (Table 13). It is likely that one has been a stag of more than 4 years old (Individual 1); one possibly a hind of more than 4 years old (Individual 2) and 2 are calves less than one year old (Individual 3 and 4), one of them probably a young male (Individual 4).

Table 13. **EMNI** estimation for **Red deer** on the following bones: Ulna, Radius+Ulna, Metacarpal, Tibia, Metatarsal, Phalanx I and II; proximal (prox), distal (dist), left (L), right (R), unfused (unfus), fused (fus), year (y). Estimated value underlined. Measurements in mm.

Red deer

		Ind. 1	**Ind. 2**	**Ind. 3**	**Ind. 4**
Ulna prox	L	1 fus	–	–	–
	R	–	1 fus	–	–
Ulna dist	L	–	–	1	1 unfus
	R	–	–	–	1 unfus
Radius+Ulna prox	L	–	1 >4y	–	–
	R	–	–	–	–
Metacarpal dist	L	–	1 >3y	– <3y	1 <3y
	R	–	–	2 <3y	–
Tibia dist	L	1 fus	–	–	–
	R	–	–	–	2 unfus
Metatarsal dist	L	–	1 >3y	–	–
	R	–	–	–	–
Phalanx I		1	–	3 <1y	1 <1y
Phalanx II		1	–	3 <1y	–
Ulna	DPA	57.1L	43.3R	–	–
Metacarpal	Bd	–	37.5L	31.8R	–
Tibia	Bd	48.5R	–	–	48.5R
Tibia	Dd	39.2L	–	–	38.3R
Phalanx I	Glpe	55.7	–	–	–
	Bp	20.2	–	–	–
Phalanx II	Gl	43.7	–	–	–
	Bp	20.8	–	–	–
Age		>4 years	>4 years	<1 year	<1 year
Sex		♂	♀ ?		♂ ?

Casteel's method has been applied to all 183 fragments identified as red deer. His formula for small samples has been used. The calculations gave a result of 12 individuals, a number three times larger than the EMNI estimation.

4.1.5 Roe deer (Capreolus capreolus); 1 individual (the EMNI estimation)
2 individuals (Casteel's method)

There are at least remains of one individual in the material. No more accurate age determination has been possible since suitable bone elements, for instance unfused epiphyses and teeth, are missing. However, considering one half of a mandible and specimens of limb bones (radius, ulna and femur) it is suggested that the individual was adult. The limb bones seem to have belonged to a fully grown animal both as to size and morphology. The same is the case for the mandible specimen (Table 59). Certainly all teeth are missing but it is clearly visible that all cheek teeth had erupted. Probably the mandible comes from a buck, since the mandibular angle shows a certain extension (Boessneck 1973, p 26). There is also a burnt skull fragment with remaining part of the burr in the material.

Applying Casteel's formula for small samples to the 7 pieces identified as roe deer the result was 2 individuals.

4.1.6 Pig (Sus scrofa and Sus scrofa f. domestica); 7 individuals (the EMNI estimation)
27 individuals (Casteel's method)

Specimens of teeth are the basis of the assessments of age for all the young individuals. Teeth are present in a relatively large number in the material and can, even when they are not attached to maxillary or mandibular fragments, rather easily be identified as to place and side. Considering the teeth in general, both erupting time, wear and size are used in the assessment. Furthermore, epiphyseal fusion, morphology, measurements and size of some limb bones and phalanges are used (Table 14). Sex determinations are suggested for two of the individuals. The determinations are based on the occurrence of a whole female lower canine and fragments of at least one male lower canine. These criteria indicate that there are remains of at least one sow and one adult boar. Taking all the characteristics mentioned above into consideration the EMNI estimation gives 7 individuals. It is likely that one has been more than 4 years old, probably rather old, taking into account the fused diaphysis of a radius + ulna (Individual 1); one more than 3.5 years old (Individual 2); one more than 2.5 years (29 months) but less than 3.5 years old (Individual 3); one more than 7 but less than 13 months old (Individual 4); one more than 7 months but less than one year old (Individual 5); one more than one month but less than one year (Individual 6) and one more than one month but less than 14 weeks old (Individual 7). It is suggested that Individual 1 is a female and that Individual 2 is a male (Table 14).

Casteel's method has been applied to all 937 fragments identified as pig, and his formula for small samples has been used. The calculations gave a result of 27 individuals which, as for cattle, is a considerably higher value than the EMNI estimation.

Table 14. **EMNI** estimation for **Pig** on the following teeth and bones; Deciduous incisors (i^1, i^2, i^3), molars (m^4, m_4), permanent Incisors (I^3), Canine (C_1), Premolars (P_1, P_4), Molars (M^1, M^2, M_2, M^3), Humerus, Ulna Radius+Ulna, Tibia, Phalanx II; left (L) right (R), year (y) month (m), week (w), Measurements in mm.

Pig

		Ind. 1	Ind. 2	Ind. 3	Ind. 4	Ind. 5	Ind. 6	Ind. 7
i^1	L	–	–	–	–	–	–	1 >1m
	R	–	–	–	–	–	–	–
i^2	L	–	–	–	–	–	–	–
	R	–	–	–	1 >12w	1 >12w	–	–
i^3	L	–	–	–	–	–	1	1
	R	–	–	–	–	–	1	1
m^4	L	–	–	–	1	–	–	–
	R	–	–	–	1 >4w	1 >4w	–	–
m_4	L	–	–	–	–	1	–	–
	R	–	–	–	1 >7w	1 >7w	–	–
I^3	L	–	–	–	–	1	–	–
	R	–	–	–	–	– <1y	–	–
C_1	L	1 very	fragm.	–	–	–	–	–
	R	– worn		–	–	–	–	–
P_1	L	–	–	–	1	1	–	–
	R	–	–	–	– >7m	– >7m	–	–
P_4	L	–	–	1	–	–	–	–
	R	–	–	1 >16m	–	–	–	–
M^1	L	–	–	–	–	–	–	–
	R	–	–	–	1 >6m	–	–	–
M^2	L	–	–	–	–	–	–	–
	R	–	–	1 >13m	–	–	–	–
M_2	L	–	–	–	1	–	–	–
	R	–	–	–	– <13m	–	–	–
M^3	L	–	–	1	–	–	–	–
	R	–	–	1 >29m	–	–	–	–
Humerus	L	–	–	1	1	1	–	–
	R	–	–	1 <3.5y	– <3.5y	1 <1y	–	–
Ulna	L	–	1	1	–	–	–	–
	R	–	– >3.5y	1	–	–	–	–
Radius+Ulna	L	1 fused	–	–	–	–	–	–
	R	–	–	–	–	–	–	–
Tibia	L	–	–	1	–	–	–	–
	R	–	1 >2y	– >2y	–	–	–	–
Phalanx II (Metapodial III/IV)		–	–	–	–	3 <1y	2 <1y	–
Tibia	BD	–	37.4R	32.1L	–	–	–	–
Age (y, m, w)		>4y	>3.5y	>29m	>7m	>7m	>1m	>1m
Sex		♀	♂	<3.5y	<13m	<1y	<1y	<14w

4.1.7 Wolf (Canis lupus); 1 individual (the EMNI estimation)
2 individuals (Casteel's method)

In the material there are remains of at least one, probably adult, individual. There are only specimens slightly damaged by fire or burnt. The assessments of age are based on measurements of one whole metacarpal II, put together from 3 pieces, and fragments of metacarpal IV, as well as on size and morphology of the bones. Among wolf the epiphyseal cartilage of the long bones closes at about one year of age marking the end of this species skeletal growth. By this time and even earlier it is very difficult to physically distinguish a young wolf from a mature one. The wolf, however, does not reach sexual maturity until the end of the second year (Mech 1970, p 141–143).

Applying Casteel's formula for small samples to the 6 bone elements identified as wolf the result was 2 individuals.

4.1.8 Dog (Canis lupus f. familiaris); 1 individual (the EMNI estimation)
1 individual (Casteel's method)

There are only three specimens identified as dog in the material. An unfused distal epiphysis of a femur indicates an individual younger than 18 months. As to size and morphology it cannot be excluded that the other two, a fragment of the first cervical vertebra *(atlas)* and a fragment of the cheek bone *(os zygomaticum),* come from the same individual. Furthermore, all of the three specimens were found within the same square meter.

Applying Casteel's formula for small samples the result was the same as in the EMNI estimation, that is one individual.

4.1.9 Brown bear (Ursus arctos); 1 (2) individuals (the EMNI estimation)
2 individuals (Casteel's method)

There are remains of at least one adult individual in the material. One ulna, totally complete, with well developed muscle attachments has been measured (Table 68). The measurements show a fully grown animal, probably a male. One cheek tooth, an M_3, is very worn. It has been pointed out by Degerbøl (1933, p 480–481) that the M_3 is the first of the molars to get worn. Nevertheless it seems likely that this M_3 is worn enough to indicate an old individual. There are also two premolars, P_1 and P_4, from the same side, the left, as the M_3. They are not at all as worn as the M_3. Considering this evidence the EMNI estimation indicates one fully grown and probably old male individual but, according to the premolars, there may be remains of one more younger individual.

Applying Casteel's formula for small samples to the 4 specimens identified as brown bear, the result was 2 individuals.

4.1.10 Badger (Meles meles); 2 individuals (The EMNI estimation)
5 individuals (Casteel's method)

There are no juvenile remains positively identified in the material. The basis of the EMNI estimation are specimens of maxillae, mandibles and teeth (Table 15). Measurements, size, morphology and tooth wear have been taken into consideration. The measurements used in Table 15 are maximum length (L) and maximum breadth (B) of P^4 and M^1. In the case of size and morphology diaphyses of the humerus, ulna and fibula have also been considered. Concerning the age of the badger, investigations of the skeletal age of the modern Swedish badger have been performed on tibia (Ahnlund 1976). Detailed analysis shows that during the badger's first summer both the proximal and distal epiphyses are unfused. At about 10 months of age the distal epiphysis is fused. The proximal epiphysis starts to close in the second fall and winter. Weak lines of the fusion are still discernible on the bone at an age of about 24–28 months. It seems that the variation between individuals is rather small, making the method reliable. Preliminary observations have further indicated that the tibia fusion happens rather late among the badgers. This means that the skeletal growth of the badger may in general be almost finished at about two years of age. In addition the deciduous teeth are shed early. The permanent dentition is generally complete in the middle of July in the first summer (Ahnlund 1976, p 121).

Table 15. **EMNI** estimation for **Badger** on maxilla, mandibles and following teeth: Incisors (I^2, I^3, I_1, I_2, I_3), Canines (C^1, C_1), Premolars (P^1, P^2, P^3, P^4, P_2, P_3, P_4), Molar M^1); Left (L), right (R). Measurements in mm.

Badger

	Ind. 1	Ind. 2
Maxilla with I^2, C^1, P^1–P^4	L 1	–
	R –	–
Mandible with I_1–I_3, C_1, P_2–P_4	L 1	–
	R –	–
Mandible (fragment)	L –	1
	R –	–
I^2	L –	1
	R –	–
I^3	L –	1
	R –	1
C^1	L –	1
	R –	–
C_1	L 1–	–
	R –	–
M^1	L –	–
	R 1	–
P^4 (L = max. length)	L 9.5L	–
(B = max. breadth)	B 7.6	–
M^1 (L = max. length)	L 15.4R	–
(B = max. breadth)	B 12.5R	–

The criteria of the EMNI estimation gave as a result 2 individuals. (Table 15). One (Individual 1) seems to have been a fully grown individual more than 2 years old, probably older, and possibly a male on the evidence of the maxilla, mandible, teeth and limb bones. One premolar, P_1 is absent in the mandible and seems never to have developed. Distally there is a root of M_1 remaining in the jaw, the other alveoli exhibit bone remodeling (Section 7.1.10). The other (Individual 2) seems to have been a smaller animal on the evidence of the size and morphology of a mandible fragment and teeth.

Casteel's method has been applied to all 36 fragments identified as badger. Using his formula for small samples the calculations gave an estimate of 5 individuals.

4.1.11 Pine marten (Martes martes); 4 individuals (the EMNI estimation)
9 individuals (Casteel's method)

No juvenile remains have been positively identified in the material. The basis of the EMNI estimation are above all specimens of mandibles and teeth, taking into consideration measurements (the maximum length (L) of P^4 and M_1), size, morphology and wear. In the case of size and morphology, specimens of the limb bones, especially ulna and tibia, have also been used (Table 16). Concerning the age of the pine marten, it has been pointed out that the growth of this species is already finished during the first season and that it is fully grown in the autumn (Ahnlund, pers. comm.). Probably there are remains of both males and females, since the teeth osteometrically and also the mandibles morphologically show important differences. For example the maximum length of the carnassial tooth, M_1, corresponds to both the smallest length of recent Danish females as well as to the largest length of recent Danish males (Table 72). It is possible that there are also remains of both younger and older animals in the material, since the degree of wear differs considerably among carnassial and also other teeth.

Taking all criteria of the EMNI estimation into consideration the result gave an estimate of 4 individuals. In Table 16, according to dimensions, size and wear of M_1, the individuals are numbered 1 to 4.

Applying Casteel's method to all the pine marten fragments (115 pieces) and using his formula for small samples, the result was 9 individuals. In this case, using Casteel's method more than doubled the number of individuals attained by the EMNI estimation.

4.1.12 Lynx (Lynx lynx); 1 (2) individuals (the EMNI estimation)
1 individual (Casteel's method)

There is one juvenile individual identified in the material. The age assessment and the EMNI estimation are based on one unfused distal epiphysis of metacarpal II.

Studies of the age of the wild lynx have been performed on the modern lynx i Norway (Kwam 1979). The investigations include studies of annuals of the cement layers of the teeth and also the time of sexual maturity. The results show

Table 16. **EMNI** estimation for **Pine marten** on mandibles and the following teeth: Canines (C^1, C_1), Premolars (P_1, P_2, P_3, P^4, P_4), Molars (M^1, M_1, M^2, M_2), and bones: Ulna, Tibia; left (L), right (R). Measurements in mm.

Pine marten

		Ind. 1	Ind. 2	Ind. 3	Ind. 4
Mandible with C_1, PM_1–PM_4, M_1, M_2	L	–	1 slightly	–	–
	R	–	– worn	–	–
Mandible with C_1, PM_2–PM_4	L	–	–	–	1 unworn
	R	–	–	–	–
Mandible with C_1, PM_4, M_1, M_2	L	–	–	–	–
	R	–	–	–	1 unworn
Mandible	L	–	–	1	–
	R	–	–	1	–
C_1	L	–	–	1	–
	R	1	–	1	–
M^1	L	–	–	– slightly	–
	R	–	–	1 worn	1 unworn
M_1	L	1 worn	– slightly	– slightly	1 unworn
	R	1	1 worn	1 worn	–
M^2	L	1 worn	–	1 slightly	–
	R	1	–	1 worn	–
M_2	L	–	– slightly	–	–
	R	–	1 worn	–	–
Ulna	L	1	–	1	1
	R	–	–	1	–
Tibia	L	–	–	1	–
	R	–	–	1	1
P^4 (L = max. length)	L	–	–	9.6R	9.2R
M_1 (L = max. length)	L	10.7L 10.8R	10.1L	9.6R	9.1L 9.2R
Tibia	BD	–	–	10.1L	

a high mortality during the first year of life. On the other hand, individuals surviving their first year of life often attain a rather advanced age, about 12 years. After this age the mortality increases fast. The sexual maturity occurs at about 2–3 years of age.

According to this it is here suggested that the lynx has attained its full growth, that is also is skeletally adult, at about 3 years of age, possibly earlier. As regards the juvenile specimen of metacarpal II it has been suggested that it may probably come from an individual which has been killed before one year of age, since the paws of the lynx have attained their full growth very early in the animal's life (Jonsson, pers. comm.).

There is also a burnt diaphysis fragment of a radius in the material. Size and morphology of the specimen indicate rather an adult individual, that is older than 3 years. Nevertheless, it is likely that this fragment belongs to a burnt proxi-

mal right part of a radius, put together of several pieces, and which turned out to be worked into a bone implement.

Applying Casteel's formula for small samples to the 2 fragments identified as lynx, the result was the same as in the EMNI estimation namely, one individual.

4.1.13 Wild cat (Felis silvestris); 2 individuals (the EMNI estimation) 4 individuals (Casteel's method)

No juvenile remains have been positively identified in the material. Two proximal left specimens of radius (fused by domestic cat about 8.5 months of age (Habermehl 1961, p 151)) are the basis of the EMNI estimation. Teeth and other postcranial elements are also used considering measurements, size and morphology. The measurements used for the premolars are maximum length and breadth (L, B). Considering all the criteria, 2 individuals are identified (Table 17). The first (number 1) seems to have been a fully grown and heavily built animal, as indicated by the size of the premolars, P^4, (Degerbøl 1943, p 170), size of one phalanx II, as well as the appearance of specimens of radius, tibia and fibula (even if they were not measurable). The other (number 2) seems to have been a smaller and more slenderly built animal, considering the size and morphology of the postcranial bone elements. Furthermore, there is one specimen of a parietal bone with an open suture and no marked muscle attachments. Possibly such evidence may indicate the presence of a female or younger individual in the material.

Table 17. **EMNI** estimation for **Wild cat** on the following teeth and bones: Premolars (P^4), Scapula, Radius, Phalanx II (Metatarsal III or IV); proximal (prox), left (L), right (R). Measurements in mm.

Wild cat

		Ind. 1	Ind. 2
PM^4	L	1	–
	R	1	–
Scapula	L	–	1
	R	–	–
Radius prox	L	1	1
	R	–	–
Phalanx II		1	–
P^4 (L = max. length)	L	11.5L,R	–
(B = max. breadth)	B	5.8L,R	–
Radius	Bp	–	9.0L
Phalanx II	GL	16.0	–
	Bp	6.0	–
	Bd	4.9	–

Casteel's method has been applied to all wild cat fragments (26 pieces). Using his formula for small samples the result was 4 individuals, doubling the result of the EMNI estimation.

4.1.14 Beaver (Castor fiber); 1 individual (the EMNI estimation)
2 individuals (Casteel's method)

There are remains of at least one individual in the material. The EMNI estimation is based on one part of a cheek bone *(os zygomaticum),* the right maxilla and one, nearly whole, incisor (I_1). The fragments seem to have come from an adult animal. Furthermore there are three extra fragments of incisors. The beaver has been considered to be adult when it is older than 2.5 years (Lieberkind 1940a, p 447). Another author (Hatting 1969) points out that the fusion of epiphyses to diaphyses is complete by 2 years of age.

In order to investigate length as a function of age of modern Swedish beaver diagrams have been made (Lavsund, pers.comm.). According to the diagrams the length seems to be stabilized at about one meter and at an age of about 3 years with an interval of ± 1 year. This may indicate that the skeletal growth of the beaver is not quite finished until about 3 years of age.

Applying Casteel's formula for small samples to the 6 fragments identified as beaver, the calculations suggest 2 individuals.

4.1.15 Mountain hare (Lepus timidus); 1 individual (the EMNI estimation)
3 individuals (Casteel's method)

There are remains of at least one skeletally grown individual in the material. The EMNI estimation is based on specimens of a proximal and a distal tibia with fused epiphyses and specimens of incisors and molars. In order to investigate the epiphyseal junction of limb bones as an indicator of skeletal age, studies have been performed on humerus (proximal end) and also on radius and ulna (distal ends) from some modern Norwegian populations of mountain hare (Walhovd 1965, p 16 – 21). The studies showed that at an age of 7 – 9 months the epiphyseal cartilage had completely ossified in humeri from the majority of young animals. However a curved line could still be visible for some time. Radii and ulnae from nearly grown juvenile animals seemed to very much resemble those from adults, when regarded from the front. The epiphyseal line was best seen from a lateral view of the same bones. In a few cases also the hind legs, femur (distal end) and tibia (proximal end), were studied. The result indicates that the epiphyseal line disappears earlier in these bones than in humerus.

Consequently, since in the Eastern Trench material the tibia proximally shows a complete fusion, it is likely to come from an individual, which has been older than 9 months.

Applying Casteel's formula for small samples to the 12 fragments identified as mountain hare, the result gives an estimate of 3 individuals.

4.1.16 Ground vole (Arvicola terrestris); 2 individuals (the EMNI estimation)
4 individuals (Casteel's method)

The assessment of age is based on the epiphyseal fusion of limb bone epiphyses. Considering also body side of the limb bones, the EMNI gives an estimate of two individuals (Table 18). One (Individual 1) is likely to have been adult on the evidence of epiphyseal fusion; the other (Individual 2) juvenile on the evidence of the epiphyseal fusion.

Applying Casteel's formula for small samples to all fragments (22 pieces), identified as ground vole the result was 4 individuals.

Table 18. **EMNI** estimation for **Ground vole** on the following bones: Humerus and Tibia; proximal (prox); diaphysis (diaf), distal (dist).

Ground vole

	Ind. 1	Ind. 2
Humerus prox	L –	–
	R –	1 unfused
Humerus dist	L 1 fused	1 fused
	R –	–
Femur whole	L 1 fused	–
	R 1 fused	–
Tibia dist	L 1 fused	–
	R 1 fused	–
Tibia diaf	L –	–
	R –	1

4.1.17 Field vole (Microtus agrestis); 1 individual (the EMNI estimation)
2 individuals (Casteel's method)

There are remains of at least one individual. No assessment of age has been made. The EMNI estimation is based on two mandible halves with M_1 present, one from the right and one from the left side.

Applying Casteel's method and using his formula for small samples to all field vole fragments (8 pieces), the result was 2 individuals.

4.1.18 Common shrew (Sorex araneus); 1 individual (the EMNI estimation)
1 individual (Casteel's method)

There is one individual represented in the material. Only one specimen is identified, a right mandibular half M_1 and M_2 present. No assessment of age has been made.

Applying Casteel's formula for small samples to the mandible gives the same result as the EMNI estimation; one individual.

4.2 Birds

The remains of bird represent a small amount, 7.0 g (0.04 %) and 15 fragments (0.4 %) of the identified bone material from the Eastern Trench. Of the bird remains 6.4 g (91 %) and 11 fragments (73 %) represent seven species and two major taxonomic groups. The rest, 0.6 g (9 %) and 4 fragments (27 %), has only been identified as bird in general *(Aves species)* (Tables 6 and 7). Only one bone specimen is noted as damaged by fire. All but one species are represented by one fragment each. It is only the crane, which is represented by two fragments (Table 19). None of the fragments has been identified as coming from juvenile

Table 19. **Birds.** Distribution of number of fragments (n) of different skeletal elements among species and groups of species. Left (L), right (R), no body side (U)

Skeletal element	**Crane** (Grus grus)			**Heron** (Ardea cinerea)			**Capercaillie** (Tetrao urogallus)			**Teal** (Anas crecca)			**Wood pidgeon** (Columba palumbus)			**Meadow pipit** (Anthus pratensis)			**Tree pipit** (Anthus trivialis)			**Wild duck species** (Anatidae species)	**Meadow pipit/Tree pipit** (Anthus prat. triv.)	**Bird** (Aves species)		n
	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	U	L	U		
Costae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3		3
Sternum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–		1
Coracoid	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Furculum	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Scapula	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–		1
Humerus	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–		2
Radius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		1
Ulna	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–		1
Carpometacarpus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1*	–	–		1
Tibiotarsus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–		1
Digit II	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Total	2			1			1			1			1			1			1			2	1	4		15

* Damaged by fire

birds. In this case the EMNI estimation corresponds to a very simple MNI estimation, where one fragment represents one individual:

Crane *(Grus grus)*	1 individual (the EMNI estimation)
Heron *(Ardea cinerea)*	1 individual (the EMNI estimation)
Capercaillie *(Tetrao urogallus)*	1 individual (the EMNI estimation)
Teal *(Anas crecca)*	1 individual (the EMNI estimation)
Wood pigeon *(Columba palumbus)*	1 individual (the EMNI estimation)
Meadow pipit *(Anthus pratensis)*	1 individual (the EMNI estimation)
Tree pipit *(Anthus trivialis)*	1 individual (the EMNI estimation)

Hence the number of estimated individuals is seven.

4.3 Fish

The remains of fish represent 76.7 g (0.4 %) and 429 fragments (10 %) of the identified bone material from the Eastern Trench. Of the fish remains 71.2 g (93 %) and 352 fragments (82 %) have been identified to represent eight species and one major taxonomic group. The rest, 5.5 g (7 %) and 77 fragments (18 %), has only been identified as fish in general *(Pisces species)* (Tables 6 and 7). About 96 % by weight and 95 % of the fish fragments are unburnt. Only 0.4 g and 4 fragments are just damaged by fire and 3.0 g and 18 fragments are burnt, representing together 4 % by weight and 5 % by number.

The number of different bone elements present in a fish skeleton is, the scales excluded, great. In the material from the Eastern Trench 352 fish bones are distributed in eight species and one major taxonomic group. This means that the numbers of fragments of different identified bone elements per species are generally very small, but with some exceptions (Table 20). Teeth and jaw fragments *(dentale)* of pike, scales and fin-carriers *(pterygoiphori)* of perch and vertebrae of whitefish and bream are the most common specimens. Among them only jaw fragments can be identified as to side of body represented. Hence it has been considered neither useful nor significant to undertake a MNI estimation of the number of individuals of the kind used in, for example, the analysis of fish bone material from Haithabu (Lepiksaar 1977a). As regards the Eastern Trench material an attempt has been made only to estimate the numbers of individuals of different species by using Casteel's method and his formula for small samples on all fragments identified as pike (102 pieces), perch (47 pieces), whitefish (41 pieces), bream (92 pieces), tench (4 pieces), roach (5 pieces), rudd (5 pieces) and on one fragment of ide. The calculations suggest the following numbers of individuals:

Pike *(Esox lucius)*	9 individuals (Casteel's method)
Perch *(Perca fluviatilis)*	6 individuals (Casteel's method)
Whitefish *(Coregonus species)*	5 individuals (Casteel's method)
Bream *(Abramis brama)*	8 individuals (Casteel's method)
Tench *(Tinca tinca)*	2 individuals (Casteel's method)
Roach *(Rutilus rutilus)*	2 individuals (Casteel's method)
Rudd *(Scardinius erythrophthalmus)*	2 individuals (Casteel's method)
Ide *(Leuciscus idus)*	1 individual (Casteel's method)

Hence the total number of estimated individuals is 35.

Table 20. **Fish.** Distribution of number of fragments (n) of different skeletal elements among species and group of species. Left (L), right (R), no body side (U).

Skeletal element	**Pike** (Esox lucius)			**Perch** (Perca fluv.)			**Whitefish** (Coregonus sp			**Bream** (Abramis br.)			**Tench** (Tinca tinca)			**Ide** (Leuc. idus)			**Roach** (Rutilus r.)	**Rudd** (Scard. eryt.)	**Carp** fam. (Cyprinidae)	n
	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	U	U		
Frontale	–	–	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		4
Parietale	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Parasphenoidale	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		3
Ectethmoidale	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Parethmoidale	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Basipterygoideum	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–		1
Metapterygoideum	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Ectopterygoideum	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Entopterygoideum	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Praeoperculare	1	3	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–	–	–	2		8
Interoperculare	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Posttemporale	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Os Quadratum	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Articulare	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Dentale	3	5	10	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–		20
Premaxillare	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Maxillare	1	–	1	1	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–		5
Hyomandibulare	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–		1
Supramaxillare	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Palatinum	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Os Pharyngium inf	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–		4
Os Pharyngium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–	4		7
Dentes	–	23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		23
Cleitrum	2	2	–	1	1	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–		8
Supracleitrale	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Urohyale	–	–	4	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1		6
Epihyale	1	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		4
Costae	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	8		10
Vertebrae praecaud.	–	–	10	–	–	5	–	–	24	–	–	34	–	–	–	–	–	2	–	2		77
Vertebrae caudales	–	–	3	–	–	3	–	–	10	–	–	54	–	–	3	–	–	1	1	2		77
Vertebrae	–	–	1	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	29		34
Pelvis	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Hypurale	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		2
Branchialia	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		3
Lepidotrichia	–	–	4	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–		8
Pterygoiphori	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Urostyl ultima	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		1
Scales	–	–	–	–	–	16	–	–	–	–	–	–	–	–	–	–	–	–	–	6		22
Fin-rays	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–		3
Total		102			47			41			92			4			1	5	5	55		352

Table 21. Number of individuals (N) of all species according to the results from the different methods being used.

Species	EMNI N	Casteel N	Poplin N	Krantz N	Lie N
Cattle	10	34	10,13,20	11,15,22	8,6
Sheep	4	7			
Elk	1	4			
Red deer	4	12			
Roe deer	1	2			
Pig	7	27			
Wolf	1	2			
Dog	1	1			
Brown bear	1(2)	2			
Badger	2	5			
Pine marten	4	9			
Lynx	1(2)	1			
Wild cat	2	4			
Beaver	1	2			
Mountain hare	2	4			
Ground vole	2	4			
Field vole	1	2			
Common shrew	1	1			
Crane	1	–			
Heron	1	–			
Capercaillie	1	–			
Teal	1	–			
Wood pigeon	1	–			
Meadow pipit	1	–			
Tree pipit	1	–			
Pike	–	9			
Perch	–	6			
White fish	–	5			
Bream	–	8			
Tench	–	2			
Ide	–	1			
Roach	–	2			
Rudd	–	2			

5. A statistical model and its use for relative quantification of faunal remains belonging to one of several related species

When analysing the skeletal remains from Alvastra pile dwelling, as in the anlysis of bone samples from many other archaeological sites, a number of fragments turned out to be identifiable only to certain groups of closely related and skeletally similar species, no further identification being possible.

In excavated bone materials this kind of fragment may be numerous, and is often disregarded with respect to the interpretation of the skeletal material as a whole. At most such fragments may be noted in the text as a pooled number or a weight of specimens which are not further identified, resulting in a quantitative under-representation of the identified species. Sometimes they induce misleading information with respect to the species involved. An example of this is the osteological 'genus' *Ovis/Capra* frequently occurring in osteological publications, in which one species may not in fact have been positively identified in the material at all. There is also the possibility that one of the species, for example sheep, is far more frequent in the material than the other, goat.

Assume, hypothetically, that in a bone sample the bone elements identified as, say, sheep have the relative frequency 80 % and the bone elements identified as, say, goat have 20 %. Then it would be reasonable to assume that the same relationship exists among the bone elements identified only to a major taxonomic group, 'sheep/goat', which consists of the two species. Within the following pages this argument shall be further elucidated.

In the animal bone material from the Eastern Trench fragments related to a group of species are at times numerous. This is the case with the fragments identified to the group named 'big ruminants' (Table 7). Furthermore, cattle dominate in the remains over elk and red deer, both as to number and weight (Table 6), and these three species form the major taxonomic group 'big ruminants'. The fragments identified to the group named 'small ruminants' (Table 7) may also be considered as rather many, especially when comparing with the number of fragments identified to the actual species involved, that is sheep, goat and roe deer (Table 6). One species, the goat, is a member of two major taxonomic groups, 'sheep/goat' and 'small ruminants'. This species is in fact not positively identified in the material at all.

In the following I will first discuss under what conditions the suggested quantification procedure is reasonable. Then I will estimate the uncertainty in the allocation of the species within the group identified material by applying a simple statistical model for the samples. The practical consequences of the methods being used are demonstrated on the bone materials identified as 'big ruminants', 'sheep/goat', 'small ruminants' and 'carp family'. This quantification question has already to some extent been discussed elsewhere (During 1985).

5.1 The basic statistical approach

This quantification method has the three following important prerequisites: 1) The conditions of identification are the same for all species involved, with

respect to taphonomical aspects such as fragmentation due to different mechanical, chemical and physical processes. 2) It is not easier to identify skeletal remains from one of the species in question more than from the other(s). 3) The observed sample is random.

Hence it is assumed that all species involved have an equal chance of being represented in the sample, that is of being preserved, found and identified. It can then be argued that the proportions of the 'specified material', the fragments identified to individual species, give a good indication of the proportional representation of the species in the 'grouped material'. This, then, provides an opportunity to make an approximation of the species proportions within the 'grouped material' and also in the total material based on the two identified species groups.

Assume that two (and for simplicity only two) skeletally similar species (a and b) exist in the material from a site, and that the number of fragments identified to a is x. Assume, furthermore, that the total number of identified fragments assigned to the two species is n. The proportion of a is x/n, whereas the proportion of b is $1 - x/n$. In addition, there is a number of fragments m which can be identified as belonging to the two species, but without possibility of deciding which one, because of the skeletal similarities. Let y be the unknown number of fragments within this 'grouped material' that belongs to the species a.

By using the proportions of the 'specified material' as a measure of the corresponding proportions of the 'grouped material' and by regarding these two as random, independent samples of a primary large bone collection, it appears reasonable to estimate y by the formula:

$$y^* = \frac{mx}{n} \tag{1}$$

This is a point estimate (a single value). Some measure of confidence, or uncertainty, of the estimate should also be established. The statistical model is used to derive an interval for y, called a prediction interval, since the number of fragments is random. This interval takes random variations into account, but only those within the model.

It is assumed that x and y are binomially and independently distributed. A value y is searched such that the hypothesis that the probabilities of the two binomial distributions are equal is not rejected, as described in the appendix.

This model is based on a dichotomy, a contrasting relationship. It can be arranged so that, for example, two different species or two groups of families within the same higher taxon, are used. If there are more than two species, the same model can be used by considering one species versus the others pooled together.

5.2 Approximation for large samples

The normal approximation is used as an approximation, assuming that n and m are large. This approximation leads to the formula (A 3) in the appendix. After a

numerical approximation, one arrives at the following simple formula for the 95 % prediction interval for y, which is the same as (A 5) in the appendix,

$$y = \frac{mx}{n} \pm 1.96 \sqrt{\frac{m(m+n)}{n} \frac{x}{n} \left(1 - \frac{x}{n}\right)} \qquad (2)$$

The rest of the 'grouped material', that is $m - y$, will be allocated to the remaining species. Accordingly, the total number of fragments, s, allocated to a will be the sum of x and y.

If one species is much more frequent than the other the prediction interval is shorter than if the species occur with the same frequency ($x/n = 0.5$). If x/n is near 0 or 1, however, the normal approximation cannot be used. This case will be discussed later on.

The use of the statistical method will for large samples be demonstrated on animal bone material from the Eastern Trench. In this case the above mentioned conditions for applying the method are judged to be fulfilled. A sample is judged to be large if the number of its specimens, that is bone fragments, is so large that the approximation does not differ much from the result of the exact calculation. A comparison of the resulting intervals is made in the appendix.

5.3 The large sample formula applied to mammals

In the material from the Eastern Trench three skeletally similar herbivores, cattle, elk and red deer are represented and identified to species, the total number of fragments being 1474. Furthermore, there are 1037 additional fragments identified to this group of animals named 'big ruminants'. These fragments, 2511 pieces in all, will be used to demonstrate the statistical formula (2) for large samples. One of the species, cattle, is a bovid, the other two are cervids. In view of this a dichotomy can be established between two closely related families within the same higher taxon. The species a, cattle, provides more than 1200 fragments. The others, b, elk and red deer, provide only a little more than 200 fragments together. The total number of fragments, n, identified to an individual species is large. The total number of fragments, m, identified to the group named 'big ruminants' is also large.

By applying (2) the 'grouped material' can be allocated to a, the bovid family, and to b, the remaining cervid family. The results are shown in Table 22.

Table 22. **Mammals.** Allocation of 'grouped material' among 'specified material'

Species	Specified material	Grouped material	Total
Cattle	1260	857–916	2117–2176
Elk and Red deer	214	121–180	335–394
Total	1474	1037	2511

Formula (2) gives $y = 886.4 \pm 29.0$, that is the interval 857–916. The length of the prediction interval, the difference between the highest and lowest value of the interval, is 59. Hence 83–88 % from the 'grouped material' is allocated to the species a, in this case cattle.

In the following chapters, when the results from the statistical method are used on the bone material, the point estimate y^* 'identifying' 886 (85 %) fragments as cattle has been used when allocating bone fragments to cattle from the 'grouped material'. This means that 2146 fragments (1260 + 886) can be identified as belonging to cattle. Consequently 151 fragments (15 %) can be allocated to elk + red deer. This means that 365 fragments (214 + 151) are identified as elk + red deer. It may be assumed that most of the fragments from the cervid family probably belong to red deer since the remains of elk are far less common in the material than the remains of red deer.

In Chapter 6 this principle is used when allocating specimens from the reconstructed groups of body regions (Group 1–11) belonging to big ruminants. 85 % of the fragments from each body region are allocated to cattle and 15 % to elk + red deer. Thus the relative frequency x/n of the total 'grouped material' is used for all reconstructed groups. Alternatively the method could have been used on each group one by one. However, the method of giving each group its own relative frequency x/n was not used, since it was judged that a calculation by dividing the material in smaller units would have increased the uncertainty too much.

In addition an attempt has been made to apply the weights of the 'grouped material' to the 'specified material'. It should be emphasized that this is done without any consideration to the further uncertainty the variation in weight may add to the estimations. The fraction $\frac{y^*}{m}$, the weight of the 'grouped material', w, and the weight of the number of fragments, v_i, identified to the species i, give the total weight, w_i, of the fragments allocated to the species i, according to the following formula (where of course the fraction $\frac{y^*}{m}$ is equal to $\frac{x_i}{n}$):

$$w_i = \frac{y_i^*}{m} \; w + v_i \; ; \; i = 1, \ldots, k \qquad (3)$$

where k is the number of species. Applying (3) on values from Tables 6 and 7 gives $\frac{886}{1037} \cdot 2554.3$ g + 11121.7 g, which equals 13304 g allocated to cattle. This means that 75.5 % by weight of the total identified animal bone material, 17.6 kg, is tentatively allocated to cattle. Applying (3) on values from Tables 6 and 7 gives $\frac{151}{1037} \cdot 2554.3$ g + 1512.8 g, which equals 1885 g allocated to elk + red deer. This means that 11 % by weight of the total identified material is tentatively allocated to elk + red deer.

5.4 The large sample formula applied to fish

When transforming 'grouped material' of fishbones into 'specified material' (2) has also been used. In this material five different species of carp are identified. The species are bream, tench, ide, roach and rudd. The total number of identified fragments, n, are 107. One species the bream, a, provides 92 fragments of the 'specified material'. The others, b, provide only 15 fragments together. In addition there are 55 fragments, m, identified simply to a major taxonomic group of carp fishes comprising closely related species. The group may conveniently be called the 'carp family'. While making these calculations it is, however, stressed that there may be remains of another carp species, silver bream, involved in the 'grouped material', and this could increase the uncertainty of any divisions. The results of the calculation according to (2) is given in Table 23.

Table 23. **Fish.** Allocation of 'grouped material' among 'specified material'

Species	Specified material	Grouped material	Total
Bream	92	41–54	133–146
Tench, Ide Roach, Rudd	15	1–14	16–29
Total	107	55	162

Formula (2) gives $y = 47.3 \pm 6.2$, the interval 41 to 54. The length of the prediction interval, the difference between the highest and the lowest value of the interval, is 13. Hence 75–98 % of the 'grouped material' is allocated to the species a, in this case bream.

In the following the point estimate y^* giving 47 (85 %) fragments to bream has in general been used when allocating bone specimens to bream from the 'grouped material' (Sections 7.3.5 and 7.3.6). This means that 139 fragments (92 + 47) will be identified as belonging to bream. Consequently 8 (15 %) fragments will be allocated to tench, ide, roach and rudd. This means that 23 fragments (15 + 8) will be identified as belonging to tench, ide, roach and rudd.

Applying (3) on values from Tables 6 and 7 gives $\frac{47}{54} \cdot 4.6\text{ g} + 16.0\text{ g}$, which equals 20 g allocated to bream.

5.5 The special case sheep/goat

As previously stressed the skeletons of sheep and goat are, from a general point of view, very much alike. Sometimes only one of them can be identified to species in a bone sample. Very often there are many fragments left which can only be identified to either sheep or goat. These fragments consitute, in archaeozoological terms, the well used category 'sheep/goat'.

In the bone material from the Eastern Trench there are 62 fragments identified to sheep, none to goat and 59 to the group sheep or goat.

According to this $x = n$, $n = 62$ and $m = 59$. The question is how many possible fragments of goat are there in the 'grouped material'?

Here the normal approximation cannot be used. Instead the exact formula indicated in (A 1) and (A 2) in the appendix is used. It is reasonable to choose a one-sided alternative in the test, since x has the extreme value n. The sum in (A 1) here reduces to a single term and a lower prediction limit for y on the level 95 %, say, is simply the smallest y value for which

$$Q = \frac{\binom{m}{y}}{\binom{n+m}{n+y}} \tag{4}$$

is at least 5 %.

When calculating Q for $y = m$, $(m-1)$, $(m-2)$, that is $y = 59,58,57$, etc., it is found that $y = 55$ gives $Q = 0.054$. Hence a one-sided prediction interval with an approximate 95 % level is $y \geqslant 55$.

In the bone sample the practical consequences are that at least 55 fragments (93 %) are allocated to sheep from the 'grouped material', while the remaining 0–4 fragments (0–7 %) is allocated to the rest of the 'grouped material', goat.

5.6 Application of the formulae to small ruminants

The species sheep, goat and roe deer are all relatively small ruminants. The species are skeletally closely similar. In the bone material from the Eastern Trench there are 7 fragments identified to roe deer, 121 fragments (62 + 59) identified to sheep and sheep/goat and 150 fragments identified to roe deer or sheep/goat (Tables 6 and 7). The group of fragments identified to roe deer or sheep/goat is here called 'small ruminants'.

Applying (2) when allocating the 'grouped material' of small ruminants among roe deer and sheep/goat gives $y = 8.2 \pm 8.0$, that is the interval 0–17. The length of the prediction interval is thus 17. The results of the calculations are given in Table 24. If calculating according to (A 3) in the appendix, one arrives at the figures given in brackets in Table 24. It is noted that in this case the approximation by (2) is not as good as in earlier examples since x is close to 0. It can, however, be seen that the difference is not great.

Accordingly 0–17 fragments (0–11 %) may be allocated to roe deer and 133–150 fragments (89–100 %) to sheep/goat. In Chapter 6 the point estimate $y^* = 8$ (or 5 %) will be used, when allocating fragments to roe deer.

Table 24. **Small ruminants.** Allocation of 'grouped material' among 'specified material'. Calculating according to (A 3) in appendix gives the figures in brackets.

Species	Specified material	Grouped material	Total
Roe deer	7	0–17 (1–19)	7–24 (8–26)
Sheep + Sheep/goat	121	133–150 (131–149)	254–271 (252–270)
Total	128	150	278

In order to proceed with further computations, that is to allocate fragments from the 'grouped material' of small ruminants to sheep and goat, one would, in fact, like to have a simultaneous allocation among the three species involved. That would, however, be complicated to compute. A simpler way, although not quite statistically correct, is to proceed in two separate steps, each of which considers two species/groups only. The first step has just been taken, and in the second step prediction regions are computed for sheep and goat for every value of roe deer within its prediction interval by using (4). This two-step procedure, however, does not keep the overall level at 95 %. The appendix notes this and it also illustrates the prediction regions in a graph. As an example, using the point estimate 8 for roe deer, the total number of fragments allocated to the group sheep/goat becomes $150 - 8 + 59 = 201$. Since there are no fragments identified to goat in the material, using (4) with $n = 62$ and $m = 201$ gives a one-sided prediction interval with an approximately 95 % level and $y \geqslant 190$.

In the following chapters, when these results of applying the statistical method to the bone material are used, only the point estimates are considered as a rule, for simplicity. Hence 263 fragments (201 + 62) are allocated to sheep, 15 fragments (7 + 8) are allocated to roe deer and no fragment is allocated to goat.

In the same way as for cattle and elk + red deer an attempt has been made to allocate the weight of the 'grouped material' to individual species, that is sheep and roe deer by using (3). In this case it is assumed that 142 fragments (150 – 8) belong to sheep.

Applying (3) on values from Tables 6 and 7 gives $\frac{8}{150} \cdot 99.8\text{ g} \quad + \quad 53.9\text{ g}$,

which equals 59 g allocated to roe deer. As regards this species it means that 0.3 % by weight of the total identified animal bone material is still identified as roe deer.

Applying (3) on values from Tables 6 and 7 gives $\frac{142}{150} \cdot 99.8\text{ g} \quad + \quad 199.6\text{ g}$,

which equals 294.1 g allocated to sheep. (The weight 199.6 g includes the 138.6 g originally identified as sheep, as well as the 61.0 g originally identified as sheep/goat.) This means that about 2 % by weight of the total identified bone material is tentatively identified as sheep.

6. Anatomical position and numerical representation of identified bone elements

In the case of the mammals they have been divided in two categories, primarily meat producing and primarily non-meat producing species. It is here argued that cattle, sheep, elk, red deer, roe deer, pig, brown bear, badger, beaver and mountain hare may all have been good meat producers. The dog is, depending on its special relationship to man, not considered as a typical meat-producing animal. The so-called non-meat producing mammals includes the wolf, pine marten, lynx and the wild cat. For some of the animals, cattle, sheep, red deer, pig, dog and wild cat and also for the category sheep/goat illustrations show their skeletons with the number of identified individual bone elements (Figs. 11–15, 17–18). For the rest, as for all major taxonomic groups, birds and fishes, tables show the numerical

Table 25. **Mammals.** Distribution of number of fragments (n) of different skeletal elements among species (not represented by bars in Figs. 11–15, 17, 18. Left (L), right (R), no body side (U).

Skeletal elements	**Elk** (Alces alces)			**Roe deer** (Capreolus cap.)			**Wolf** (Canis lupus)			**Brown bear** (Ursus arctos)			**Badger** (Meles meles)			**Pine marten** (Martes martes)			**Lynx** (Lynx lynx)			**Beaver** (Castor fiber)			n
	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	
Neurocranium	–	2	–	–	–	1	–	–	–	–	–	–	–	1	2	2	2	5	–	–	–	–	–	–	15
Visceral cranium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2
Cornua (Antler)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Os Hyoideum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dentes	–	–	6	–	–	–	–	–	–	3	–	–	16	3	–	16	14	–	–	–	–	–	–	4	62
Maxilla	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	4	2	–	–	–	–	–	–	9
Mandibula	–	–	–	1	–	–	–	–	1	–	–	–	2	–	1	2	3	–	–	–	–	–	–	–	10
Maxilla/Mandibula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Atlas or Axis	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2
Vertebrae cervicales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Vertebrae thoracales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Vertebrae lumbales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	2
Sacrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vertebrae caudales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	4
Vertebrae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Costae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	13	–	–	–	–	–	–	14
Sternum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scapula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	1
Humerus	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	2	–	–	–	–	–	–	–	5
Radius	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	4
Ulna	–	–	–	1	–	–	–	–	–	1	–	–	1	1	–	3	1	1	–	–	–	–	–	–	9
Radius + Ulna	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Carpalia	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Metacarpalia	–	1	1	–	–	–	3	–	–	–	–	–	–	–	–	–	1	1	1	–	–	–	–	–	8
Os coxae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	–	–	–	–	3
Femur	–	1	–	1	–	–	–	–	–	–	–	–	–	–	1	1	–	1	–	–	–	–	–	–	5
Patella	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tibia	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	4	1	–	–	–	–	–	–	–	7
Fibula or Os mall.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	1	2	–	–	–	–	–	–	5
Talus	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	1	–	–	–	–	–	–	3
Calcaneus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Tarsalia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Metatarsalia	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	3	3	–	–	–	–	–	–	–	8
Metapodiae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1
Phalanx I	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	5
Phalanx II	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	3
Phalanx III	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	3
Sesamoidea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total		21			7			6			4			36			115			2			6		

representation of identified bone elements (Tables 19, 20, 25 and 26). Figures and tables show whether the mammals are represented by bone specimens from many or few skeletal regions or as just single bone specimens, suggesting whether whole bodies or only parts of the animals had been brought to the pile dwelling. To demonstrate whether meaty, less meaty or other parts of the animal are represented in the material, the skeleton has been divided up into different regions and the skeletal elements grouped into eleven categories. The meaty regions are represented by three categories (1–3): 1) *spine* and *ribs*, 2) *shoulder* and *front leg*, 3) *pelvis* and *hind leg*. The less meaty regions are represented by five categories (4–8): 4) *cranium* and *mandible*, 5) *carpals* and *tarsals*, 6) *metapodials*, 7) *phalanges* and 8) *caudal vertebrae*. Finally one category each (9–11) represent: 9) *teeth*, 10) *horn core* and 11) *antler*.

Table 26. **Mammals.** Distribution of number of fragments (n) of different skeletal elements among species (not represented by bars in Figs. 11–15, 17–18) and among major taxonomic groups. Left (L), right (R), no body side (U).

Skeletal elements	**Mountain hare** (Lepus timidus)			**Ground vole** Arvicola terr.)			**Field vole** (Microtus agr.)			**Common shrew** (Sorex araneus)			**Elk/Red deer** (Alc.a./Cerv.e.)			**Big ruminants** (Bos t. Alces a., Cervus e.)			**Small ruminants** (Ovis a., Capra h., Capreolus capr.)			**Canid/Feline** fam. (Canidae/Felidae sp)	n
	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	L	R	U	U	
Neurocranium	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	1	13	–	–	10	–	146
																		3					
Visceral cranium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	10	–	–	1	–	104
																		1					
Cornua (antler)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Os hyoideum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	5
Dentes	–	–	8	6	–	2	–	–	6	–	–	–	–	–	–	–	–	22	–	–	–	–	250
																		8					
Maxilla	–	–	1	–	1	1	–	–	–	–	–	–	–	–	–	1	–	21	–	–	1	–	26
Mandibula	–	–	–	1	–	1	1	1	–	–	1	–	–	–	–	–	–	28	–	–	1	–	34
Maxilla/Mandibula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	–	–	–	–	16
Atlas or Axis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	1	–	4
Vertebrae cervicales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	51	–	–	10	–	61
Vertebrae thoracales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	53	–	–	10	1	64
Vertebrae lumbales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	27	–	–	13	–	40
Sacrum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	1	–	8
Vertebrae caudales	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	4	1	7
Vertebrae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	49	–	–	12	1	62
Costae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	97	–	–	37	–	138
Sternum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scapula	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	9	–	–	–	–	11
Humerus	–	–	–	2	1	–	–	–	–	–	–	–	–	–	–	1	1	12	–	1	4	–	22
Radius	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	7	–	–	5	–	13
Ulna	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	3
Radius + ulna	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carpalia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	1	–	3
Metacarpalia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	11	2	–	3	–	18
Os coxae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15	–	–	2	–	17
Femur	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	1	18	–	–	7	–	28
Patella	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tibia	1	1	–	1	2	–	–	–	–	–	–	–	–	–	–	3	1	15	2	–	1	–	27
Fibula or Os mall.	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Talus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	–	–	2	–	5
Calcaneus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tarsalia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Metatarsalia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	5	–	–	1	–	8
Metapodialia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	46	–	–	10	–	56
Phalanx I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	21	–	–	6	–	27
Phalanx II	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	–	–	1	–	14
Phalanx III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	2
Sesamoidea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22	–	–	1	–	23
Total		12			22			8			1			10			1037			150		3	

The total number of fragments, their weight and the relative frequency of unburnt, damaged by fire as well as burnt material are given for each species, including the 'grouped material' allocated to cattle, sheep, elk + red deer and roe deer by the statistical evaluations (Tables 27 and 29).

Tables 28 and 30 show the relative frequency of identified bone elements from different skeletal regions and their distribution among meat producing and non-meat producing species. These tables also include the 'grouped material' allocated to the species in question by the statistical methods.

By including the bone material statistically allocated to species an attempt is made to see to what degree this procedure will change the relative frequency of the species in question in the material and/or if it will change quantitatively the relationship between the different body regions. Frequency tables and bar charts (Tables 28 and 30, Fig. 16) may be interpreted as showing the anatomical selection within a site made by man and may also be used to reconstruct butchering procedures. To sum up comments on the results are presented (Sections 6.1.11 and 6.2.5).

Table 27. **Meat producing Mammals.** Number of fragments (n) and weight (g) per species with the frequencies of unburnt (UNB), damaged by fire (DBF) and burnt (B) material given in %. 'Grouped material' allocated to cattle, sheep, elk + red deer and roe deer by the statistical evaluations are included (indicated by ___). Fragments (n) and weight (g) per species of the total identified material, 17610.8 g and 4424 fragments, are given in %.

Species	n	UNB %	DBF %	B %	g	UNB %	DFF %	B %	Total n %	Total g %
Cattle	1260	92	3	5	11121.7	98	1	1	28.5	63.1
Cattle	2146	84	9	7	13304.1	94	3	3	48.5	75.5
Sheep	62	39	34	27	138.6	63	28	9	1.4	0.8
Sheep	263	41	30	29	294.1	52	28	20	6.0	1.7
Elk	21	90	5	5	205.3	93	6	1	0.5	1.2
Red deer	183	65	5	30	1279.8	89	4	7	4.0	7.3
Elk + Red deer	365	69	8	23	1884.7	86	5	9	8.3	10.7
Roe deer	7	6	–	1frg	53.9	99	–	1	0.2	0.3
Roe deer	15	63	15	22	59.2	84	2	4	0.3	0.3
Pig	937	37	4	59	1506.4	66	8	26	21.2	8.6
Brown beer	4	100	–	–	333.6	100	–	–	0.1	2.0
Badger	36	100	–	–	31.7	100	–	–	0.8	0.2
Beaver	6	100	–	–	10.4	100	–	–	0.1	0.1
Mountain hare	12	100	–	–	2.5	100	–	–	0.3	–
(Dog	3	100	–	–	1.2	100	–	–)	0.1	–

Table 28. Frequency of different **Skeletal regions** of meat producing mammals given in % of the number of fragments, including values (indicated by ═) from the 'grouped material' allocated to cattle, sheep, elk + red deer and roe deer by the statistical evaluations.

Skeletal regions	Cattle %	Sheep %	Elk %	Red deer %	Elk + Red deer %	Roe deer %	Pig %	Brown bear %	Badger %	Beaver %	Mountain hare %
1 Spine and Ribs	20 23	3 32	5 –	7 –	– 16	– 27	2	–	2	–	–
2 Shoulder and Front leg	20	25	19	21	–	57	13	25	18	–	25
3 Pelvis and Hind leg	14	20	–	–	16	35		–		–	
4 Cranium and Mandible	23 25	8 8	9 –	5 –	– 16	29 17	43	– –	22	33 –	8 –
5 Carpals and Tarsals	22	64	39	57	–	14	16	–	6	–	–
6 Metapodials	19	38	–	–	37	21					
7 Phalanges								–	–	–	–
8 Caudal vertebrae			–	–				–	–	–	–
9 Teeth	11 15		28	–	11	–	26	75	52	67	67
10 Horncores	4	1	–	–	–	–	–	–	–	–	–
11 Antler	–	–	–	10	4	–	–	–	–	–	–

Table 29. **Non-meat producing Mammals.** Number of fragments (n) and weight (g) per species with the frequency of unburnt (UNB), damaged by fire (DBF) and burnt (B) material given in %. Number (n) and weight (g) per species of the total identified material, 17610.8 g and 4424 fragments, are given in %.

Species	n	UNB %	DBF %	B %	g	UNB %	DFB %	B %	Total n %	Total g %
Wolf	6	–	50	50	15.9	–	71	29	0.1	0.1
Pine marten	115	86	4	10	39.5	92	3	5	2.6	0.2
Lynx	2	50	–	50	4.5	50	–	50	–	–
Wild cat	26	89	11	–	11.2	82	18	–	0.6	0.1

Table 30. Frequency of different **Skeletal regions** of non-meat producing mammals given in % of the number of fragments of pine marten and wild cat. For wolf and lynx are only the number of fragments (n) given.

Skeletal Regions	Wolf n	Pine marten %	Lynx n	Wild cat %
1 Spine and Ribs	–		–	
2 Shoulder and Front leg	–	38	1	39
3 Pelvis and Hind leg	1		–	
4 Cranium and Mandible	1	18	–	31
5 Carpals and Tarsals	–		–	–
6 Metapodials	4	18	1	11
7 Phalanges	–		–	
8 Caudal vertebrae	–		–	–
9 Teeth	–	26	–	19

6.1 Meat producing mammals

6.1.1 Cattle (Bos primigenius f. taurus) Fig. 11

There are great numbers of fragments from all skeletal regions, of both meaty and less meaty parts, present in the material. The whole spinal column with the ribs where among others the brisket, the beefsteak and the fillet are to be found

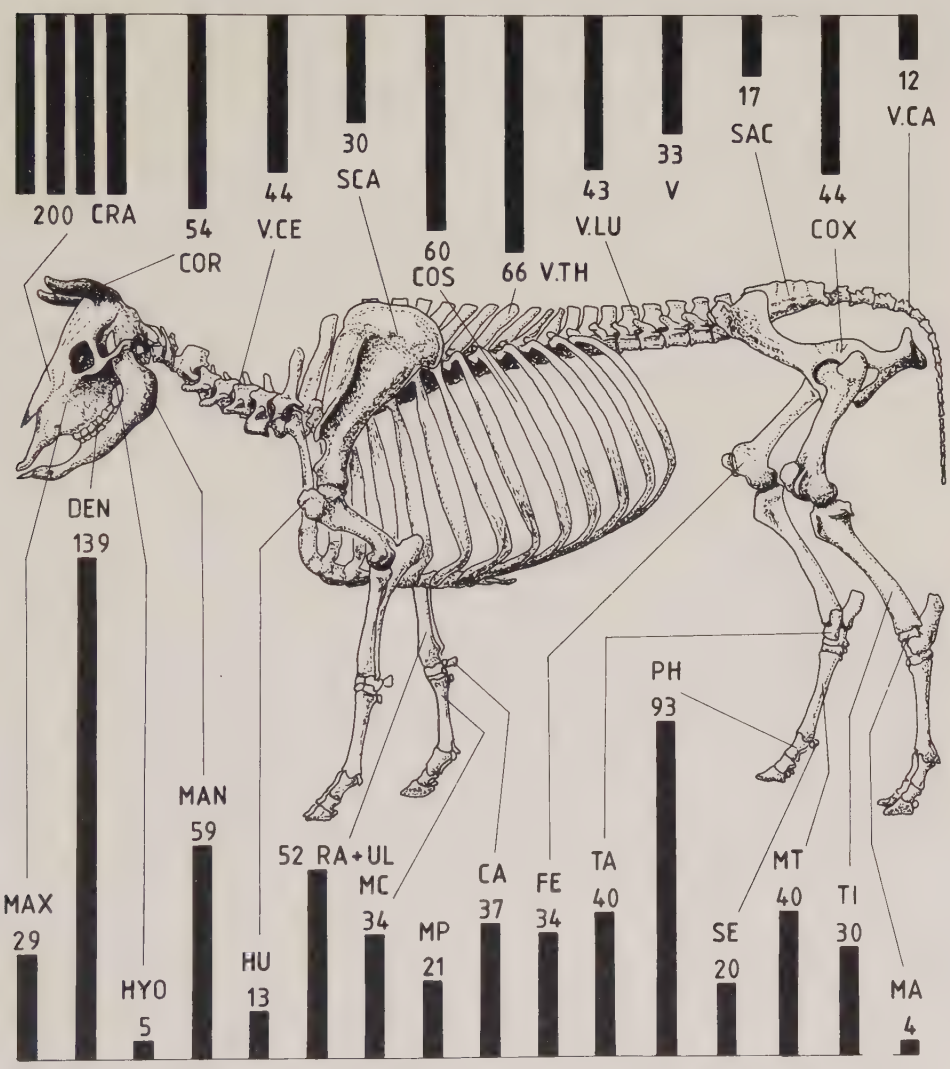

Fig. 11. CATTLE (1260 fragm; 11 121.7 g). CA = Carpi, COS = Costae, COR = Cornua, COX = Coxae, CRA = Cranium, DEN = Dentes, FE = Femur, HU = Humerus, HYO = Os hyoideum, MA = OS malleolare, MAN = Mandibula, MAX = Maxilla, MC = Metacarpalia, MP = Metapodialia, MT = Metatarsalia, PH = Phalanges, RA + UL = Radius et Ulna, SAC = Sacrum, SCA = Scapula, SE = Sesamoidea, TA = Tarsi, TI = Tibia, V = Vertebrae, V ca = Vert. caudales, V ce = Vert. cervicales, V lu = Vert. lumbales, V th = Vert. thoracales. (Redrawn after Nickel et al. 1961).

represent 20 % of the fragments. The scapulae and the front legs represent 10 %, while the pelvis, femora and lower hind legs, where the big rump and hind shank are to be found represent 10 %. All together these meaty parts represent thus about 40 %. The less meaty regions, the cranium, mandibles, carpal and tarsal bones, metapodials, phalanges and caudal vertebrae, represent about 45 %. The remaining 15 % is made up by specimens of teeth and horn cores (Table 28). It should be noted that the tarsal bones may be part of the hind shank in a cutting-up process. It is also to be noted that some parts of the less meaty areas, such as cranium and jaws, together account for about 23 %. These parts represent, from a nutritional point of view, important specimens since they contain brain, tongue and bone marrow. In addition the caudal vertebrae can be used in an ox-tail soup.

Cattle represent 28.5 % of the identified animal bone fragments and more than 63 % by weight. However, allocating by the statistical evaluations 85 % of the 'grouped material' named 'big ruminants' (Table 26) to cattle, about 48 % by number and about 76 % by weight are identified as cattle (Table 27). Hence the relative frequency of cattle has considerably increased. As regards the relationship between meaty and less meaty regions it remains mainly constant. The frequency of tooth specimens shows a slight increase (Table 28).

6.1.2 Sheep (Ovis ammon f. aries) Fig. 12 and Sheep/goat (Ovis ammon f. aries/Capra ibex f. hircus) Fig. 13

In comparision with cattle, sheep are not well represented with respect to all skeletal regions. Specimens of scapula, ribs, mandibles, teeth and horn cores are missing. There are only three fragments of vertebrae present, all atlas bones. From the meaty front legs there are only one humerus and one forelimb specimen. Pelvis and all hind legs are present. This is the part of the body where the roast is to be found. Together the meaty regions represent about 28 % of the sheep bones. The less meaty regions are far better represented. Cranial fragments, carpal and tarsal bones, metapodials and phalanges form together more than 70 %, with cranium fragments accounting for only about 8 % (Table 28). As for cattle it is here noted that the tarsal bones may be part of the roast in a cutting-up process.

Sheep represent only 1.4 % of identified animal bones and less than 1 % by weight. If according to the statistical evaluation 93 % of the 'grouped material' sheep/goat is allocated to sheep, about 3 % by number and, say, a little more than 1 % by weight can be identified as sheep. As regards the relationship between meaty and less meaty regions the meaty ones are still represented by about 30 %. Among others, separate fragments of ribs and vertebrae for instance (Fig. 13) may be added and represent saddle, chops and flank. The less meaty parts are still represented by about 70 % of the fragments, since specimens of mandible and caudal vertebrae may be added and also a couple of fragments of horn cores (Fig. 13). Furthermore, by including the fragments allocated to sheep from the 'grouped material' named 'small ruminants' (Table 26) it means that about 6 % of all identified fragments, about 2 % by weight are identified as sheep (Table 27).

The relative frequency of sheep has thus increased distinctly in the material. This also changes the relationship between meaty and less meaty regions. Now more than 50 % comes from meaty parts, especially since there is an important increase of vertebrae and ribs. Still 8 % consists of cranial and mandible fragments. Yet parts of the shoulder and teeth are missing. Hence, using the bone specimens statistically allocated to sheep, it means also that the sheep is represented in the material by rather many different bone elements from the whole skeleton. So there is a fairly good representation of all skeletal regions except for a few areas such as the teeth and the horn cores (Table 28).

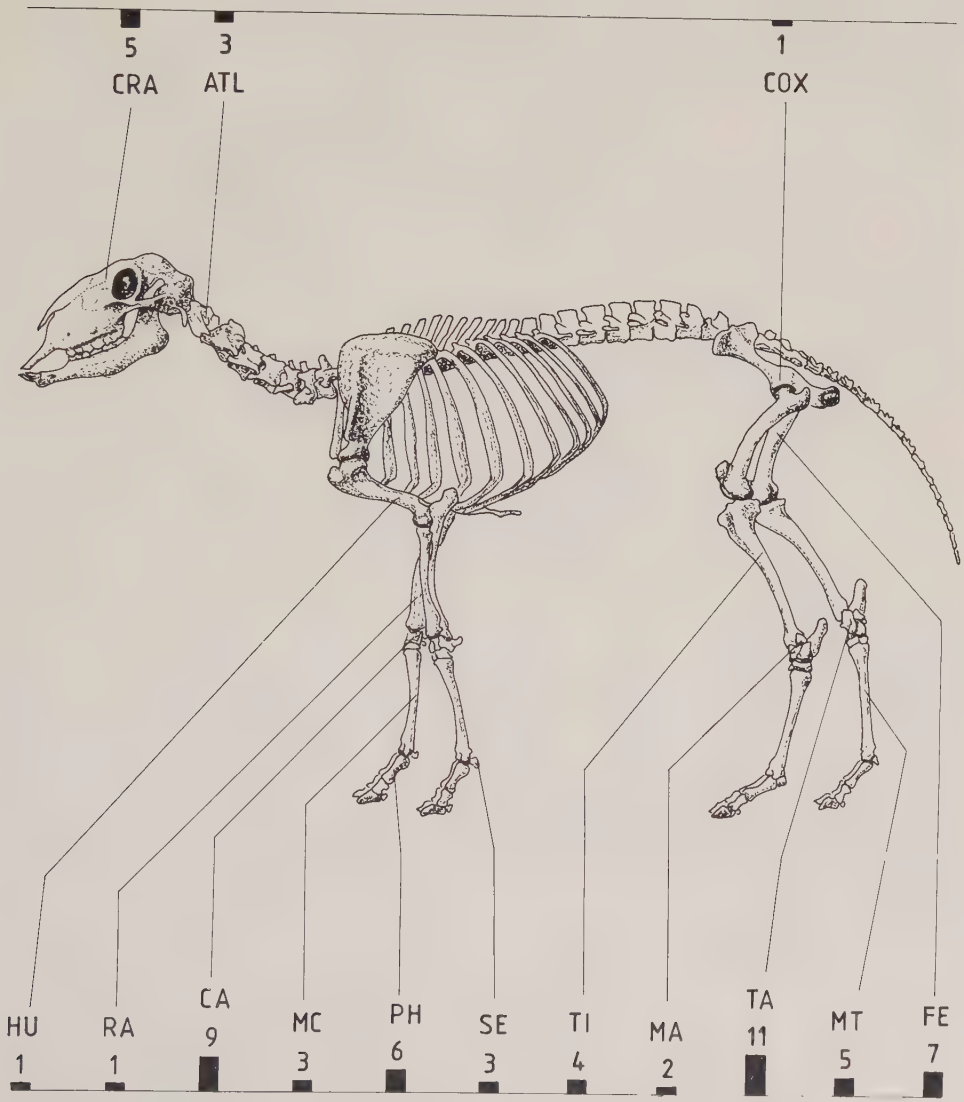

Fig. 12. SHEEP (62 fragm; 138.6 g). ATL = Atlas, CA = Carpi, COX = Coxae, CRA = Cranium, FE = Femur, HU = Humerus, MA = Os malleolare, MC = Metacarpalia, MT = Metatarsalia, PH = Phalanges, RA = Radius, SE = Sesamoidea, TA = Tarsi, TI = Tibia. (Redrawn after Nickel et al. 1961).

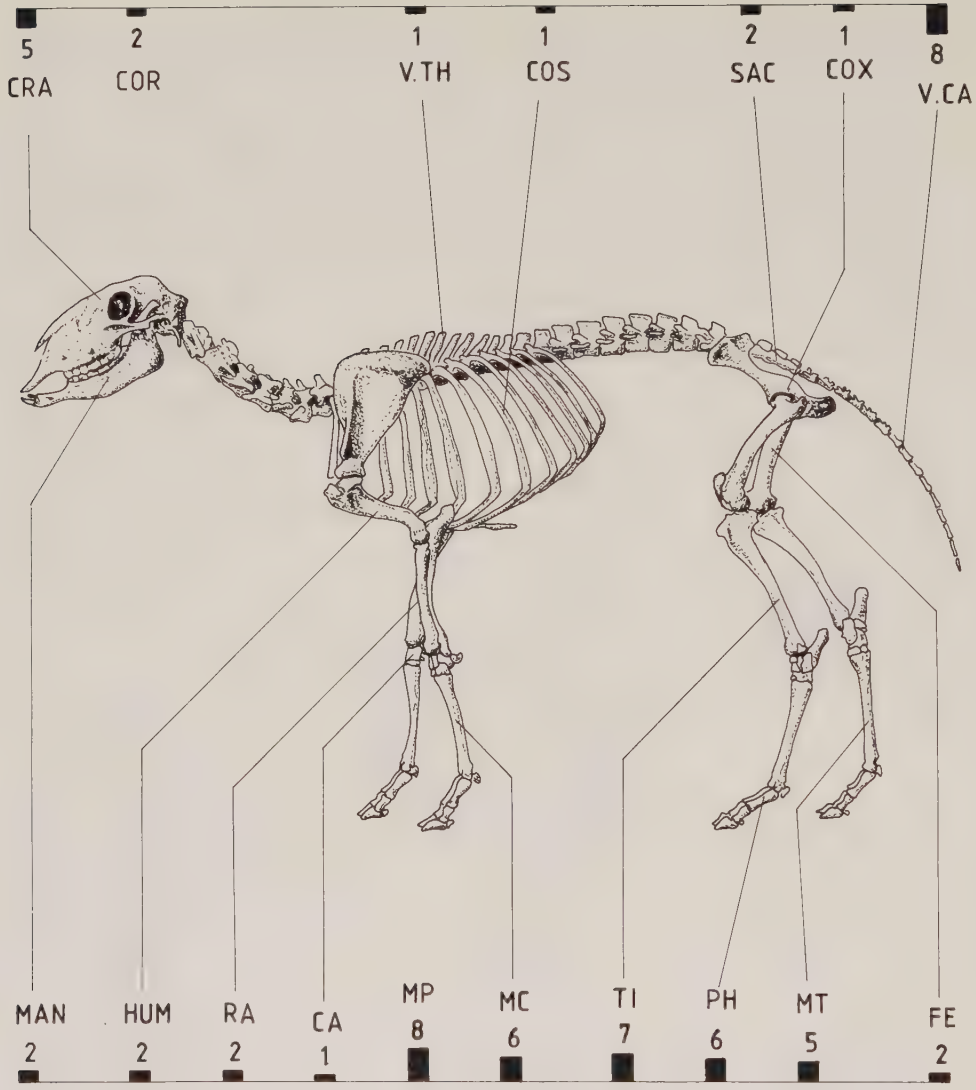

Fig. 13. SHEEP/GOAT (59 fragm; 61.0 g). CA = Carpi, COS = Costae, COR = Cornua, COX = Coxae, CRA = Cranium, FE = Femur, HUM = Humerus, MAN = Mandibula, MC = Metacarpalia, MP = Metapodialia, MT = Metatarsalia, PH = Phalanges, RA = Radius, SAC = Sacrum, TI = Tibia, V ca = Vert. caudales, V th = Vert. thoracales. (Redrawn after Nickel et al. 1961).

6.1.3 Elk (Alces alces) Table 25

There are only 21 fragments identified as elk in the material. Just four specimens, one forelimb, one femur and two lower hind leg fragments, less than 20 %, come from meaty regions. The vertebral fragment consists of an atlas fragment only. The rest, more than 75 %, comes from less meaty regions and consists of metapodials and phalanges and 6 dental fragments, all probably from the same central incisor. There are only two cranial fragments and one carpal bone (Table 28). However, even if the remains are few and some like most vertebrae,

ribs, scapulae, upper arm and tarsal bones are missing, the identified fragments indicate the presence of different body regions.

6.1.4 Red deer (Cervus elaphus) Fig. 14

There are fragments from all body regions even if some of them are represented by very few fragments. The meaty regions represent together less than 30 %. Among them the shoulder and front leg and the hind part with quarter and hind shank are

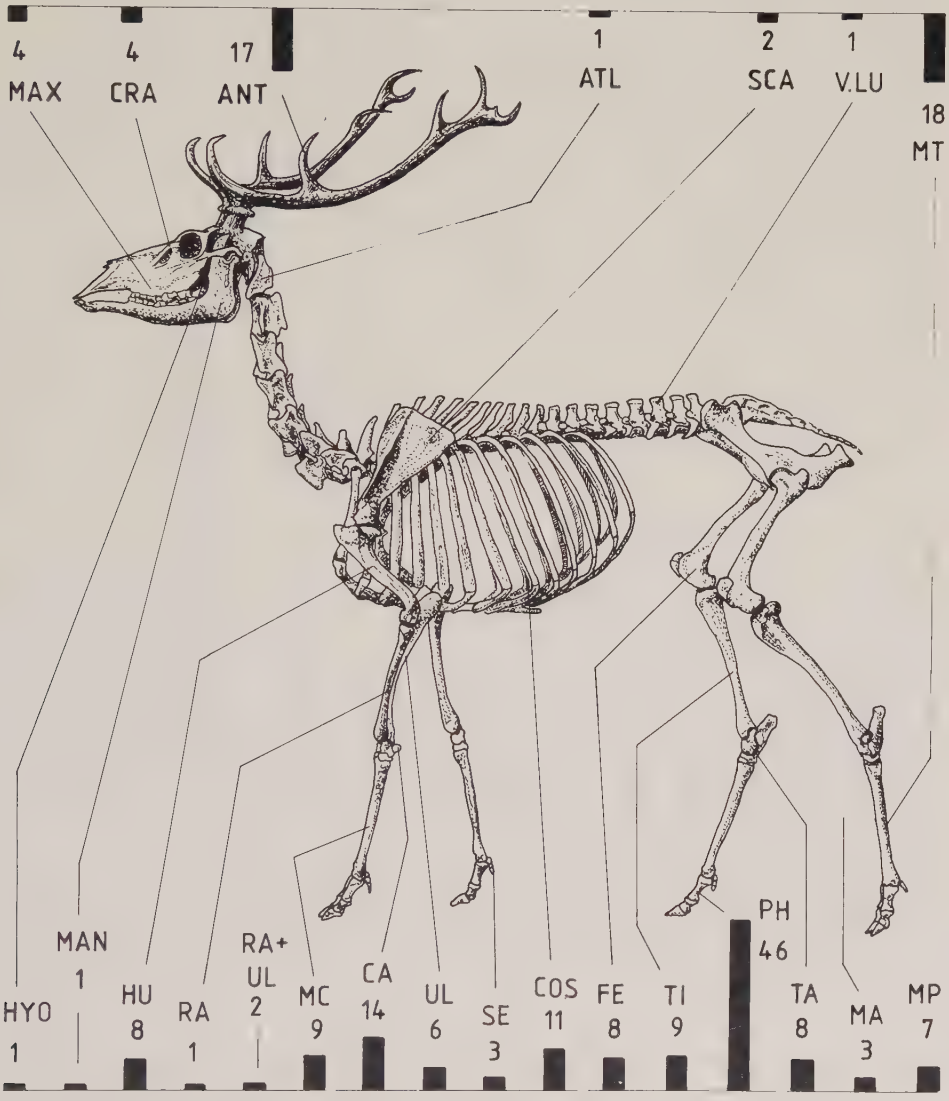

Fig. 14. RED DEER (183 fragm; 1279.8 g) ANT = Antler, ATL = Atlas, CA = Carpi, COS = Costae, CRA = Cranium, FE = Femur, HU = Humerus, HYO = Os hyoideum, MA = Os malleolare, MAN = Mandibula, MAX = Maxilla, MC = Metacarpalia, MT = Metapodialia, MT = Metatarsalia, PH = Phalages, RA = Radius, RA + UL = Radius et Ulna, SCA = Scapula, SE = Sesamoidea, TA = Tarsi, TI = Tibia, UL = Ulna, V th = Vert. thoracales. (Redrawn with addition after Ellenberger et al. 1956).

best represented, making up more than 20 %. Vertebrae and ribs represent only about 7 %. The less meaty regions represent more than 60 %. Specimens of carpal and tarsal bones, metapodials and phalanges make up the main part about 57 %. Cranium and mandible fragments correspond to only 5 %. Fragments of antler represent about 10 %. No specimens of teeth were identified. Some single bone elements are also missing for instance os coxae and sacrum, comprising the pelvic bone (Table 28).

Red deer is represented by about 4 % of the identified animal bone fragments – more than 7 % by weight. Elk makes up about 0.5 % of the number of bones, a little more than 1 % by weight. Together they form a cervid family accounting for less than 5 % of the fragments, although 8.5 % by weight (Table 27). However if, according to the point estimate values, 15 % of the 'grouped material' named 'big ruminants' (Table 26) are allocated to elk + red deer, it means that about 8 % by number and about 11 % by weight is identified as elk + red deer. Thus the relative frequency of elk + red deer is increased in the material (Table 27). With respect to these new figures, then, the distribution of different bone elements to skeletal regions is supposed to have changed. Now the large cervids are above all represented by more vertebrae, ribs, cranium and mandible fragments than were noted before. In particular, the meaty regions have a more equal representation. Likewise also a better representation of cranium and mandibles supplying brain, tongue and bone marrow is at hand. Furthermore, it also means that there are probably dental fragments from both species in the material (Table 28).

6.1.5 Roe deer (Capreolus capreolus) Table 25

There are only seven fragments identified to roe deer in the material. Three come from the forelimb and one from the femur, both representing meaty regions. The last three fragments from cranium, mandible and a carpal bone represent less meaty parts (Table 28).

Roe deer represents only 0.2 % of identified bones in the material, 0.3 % by weight (Table 27). If using the y* values 5 % of the number of fragments from the small ruminants group (Table 26) is included, then about 0.3 % by number can be identified as roe deer. The frequency of roe deer is still of course low in the material. The relationship between meaty and less meaty regions has, however, changed. Now more than 60 % comes from meaty parts (Table 28). There is thus an important increase of bone elements consisting mainly of ribs and vertebrae. This is an area of the body where, for instance, the saddle comes from. Yet, as for sheep, there are skeletal elements missing, such as scapulae and teeth.

6.1.6 Pig (Sus scrofa and Sus scrofa f. domestica) Fig. 15

There are specimens from all skeletal regions represented in the material. However, some bones definitely have a smaller representation than others. Among pigs there is no marked differences between meaty and less meaty regions since most parts, possibly apart from the tail, can be considered as attractive from a nutritional point of view, and even today pig's trotters are considered a delicacy.

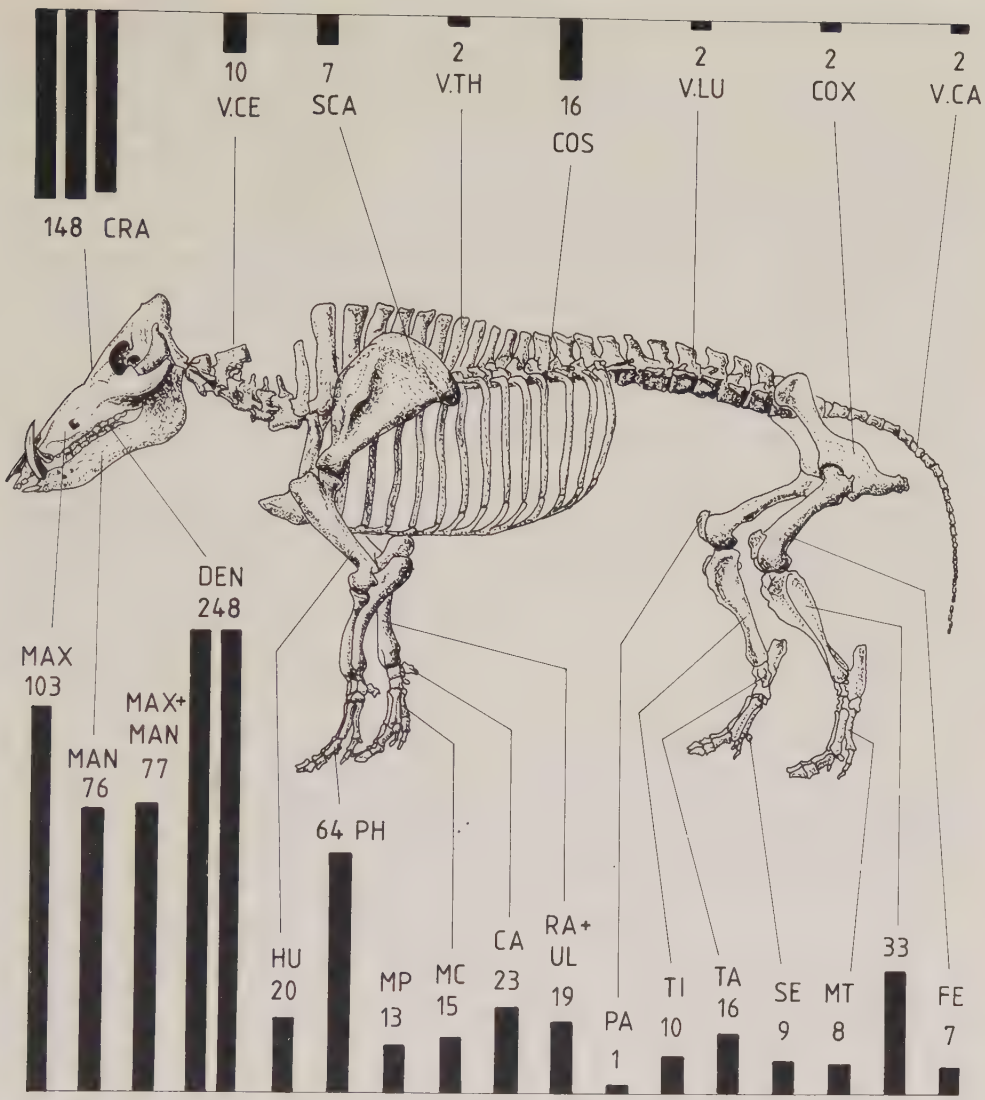

Fig. 15. PIG (937 fragm; 1506.4 g). CA = Carpi, COS = Costae, COX = Os coxae, CRA = Cranium, DEN = Dentes, FE = Femur, FI = Fibula, HU = Humerus, MAN = Mandibula, MAX = Maxilla, MAX + MAN = Maxilla / mandibula, MC = Metacarpalia, MP = Metapodialia, MT = Metatarsalia, PA = Patella, PH = Phalanges, RA+UL = Radius et Ulna, SCA = Scapula, SE = Sesamoidea, TA = Tarsi, TI = Tibia, V ca = Vert. caudales, V ce = Vert. cervicales, V lu = Vert. lumbales, V th = Vert. thoracales. (Redrawn with addition after Nickel et al. 1961).

The best represented skeletal regions are cranium and mandible with fragments, amounting to 43 %. That part of the ribs and spinal column where the loin roast, fillet, spare ribs and bacon come from have the smallest representation, with only 2 %. The front part with vertebrae, shoulder and forelimb represents about 6 %. The whole hind part with pelvis, femur and lower hind legs where ham and hind

shank are to be found represents about 7 %. The carpals, tarsals, metapodials and phalanges which include the pig's trotters represent about 15 %. It should be noted that the tarsals may be considered as part of the hind shank in the butchering process. About 26 %, a quarter of the remains, consists of specimens of teeth (Table 28).

Wild or domestic pig (or both) represent about 21 % of the identified fragments, and about 8 % by weight (Table 27). Next to cattle, pig is the most common species identified in the material, with respect to both the number of fragments and the weight. The small representation of bone elements from more meaty regions may well depend on taphonomic influences of different kinds (Chapter 2).

6.1.7 Brown bear (Ursus arctos) Table 25

There are four bone elements identified to brown bear representing 0.1 % of the total number of identified animal bones, a little less than 2 % by weight (Table 27). The remains consist of one whole forelimb, an ulna, and three teeth. As regards brown bear the forelimb is not a meaty part as would be the hind part with the ham (Table 28).

6.1.8 Badger (Meles meles) Table 25

All skeletal regions are represented in the material, although mostly as single specimens. The meaty regions are represented by single elements of vertebrae, ribs, shoulder, front and hind legs, together being about 20 %. Less meaty parts, where cranium and mandible fragments represent more than 20 %, account for about 28 %. The rest consists of one tarsal bone and one phalanx. No metapodials were found in the material. Teeth are common with more than a 50 % representation (Table 28).

Of all the identified material badger represents less than 1 % by number of fragments, about 0.2 % by weight (Table 27).

6.1.9 Beaver (Castor fiber) Table 25

There are six fragments identified to beaver, representing only about 0.1 % of both the number and the weight of animal bone material identified to species (Table 27). All specimens come from the skull region, four of which are teeth. Hence there are no identified remains of the postcranial skeleton (Table 28).

6.1.10 Mountain hare (Lepus timidus) Table 25

A quarter of the specimens, represented by one scapula and two tibia fragments are from more meaty regions. The other 75 % consists mainly of fragments of teeth. There is also one upper jaw specimen (Table 28). The remains of mountain hare represent about 0.3 % by number and only about 0.01 % by weight of all the identified material (Table 27).

6.1.11 Summary and comments

In sum it can be stated that the most common species in the material, cattle, wild or domestic pig (or both) and red deer are represented by bone specimens from all skeletal regions. With respect to some of the body regions pig and red deer are represented by only a few specimens. However, by statistically allocating 'grouped material' to already 'specified material' one can say that red deer bones from all body regions are probably better represented than initially was noted. As a result of the allocations of 'grouped material' to species it is further argued that also bone elements of sheep and roe deer should have a better representation than indicated by the material identified to species, since in that material numerous bone elements were totally missing. It is likely that, for instance, among ribs and vertebrae also the elk bones are better represented.

Furthermore, the allocation of 'grouped material' among species sometimes considerably increases the relative frequency of a species in the material, as for instance for cattle. Moreover, this procedure changes also the relationship between meaty and less meaty parts of the body in some food animals and gives a better, more even, representation of meaty parts.

Among cattle the meaty regions represent about 40 % and if the partly nutricious head and tail are included, more than 60 %. Among sheep the situation is probably the same, 60 % belonging to the meaty and nutricious regions of the body, if the allocated 'grouped material' is included. The figures 50–60 % may also be valid for elk, red deer and roe deer including 'grouped materials'. Among pig the nutricious regions account for about 75 %. In Fig. 16 it can be seen how the percentage of meaty regions increases when 'grouped materials' are allocated to particular species.

With respect to the less meaty regions the metapodials seem to be very well represented among red deer, sheep and to a certain degree also among cattle. In general these bone elements in ruminants are more likely to resist decomposition, since they largely consist of strong compact bone tissue. Compared to the long bones the ruminant short bones, the metapodials, are less rich in marrow, although it is established that the metapodials have also been subjected to marrow extraction (Table 77). Obviously they have also been attractive as raw material in manufacturing various kinds of bone implements (Table 76). Compared to the skeletons of ruminants the metapodials appear in greater number in skeletons of pigs. In view of individual separate metapodials the relationship is, generally speaking, 4:1. In the material from the Eastern Trench the metapodials of pig compose, however, less than 4 % of the remains compared to about four times that much 16 % of, for instance, the sheep remains. Taking this result into account there seems to have been a certain loss of pig metapodials in the material. This poorer representation may depend on various reasons. For instance, many of the pig bones come from juvenile individuals whose skeletons are generally less resistant to taphonomic factors, than are the adult skeletons. Moreover, wild and domestic pig are on the whole fat animals in contrast to ruminants and fat accelerates the decomposition (Noe-Nygaard 1977, p 234). Furthermore, this part

of the body, the pig's trotters, is of food value. Hence, in contrast to most other large food mammals, pig foot bones have in this respect been attractive to man. There is also evidence that they have been gnawed by dogs or other animals (Table 78) and this procedure may also have scattered them and assisted their decay. (Tables 76–78 are to be found in Section 7.1.19.)

Compared to cattle, pig and red deer the remains of elk, roe deer and badger are fairly few in the material. It has, however, been established that probably all three species are represented by bone specimens from most body regions, both meaty and less meaty ones. This also indicates that whole or parts of these animals were brought to the site. As regards brown bear and mountain hare it is assumed that at least the mountain hare is represented by skeletal elements from the meaty parts of the body. The beaver is represented by only cranium and teeth fragments.

Some of the most common skeletal elements in the material are specimens of teeth. Preservation of teeth is in general very good compared to other skeletal remains, since the teeth consist of especially hard calcified tissue. In addition it should be noted that teeth, as skeletal specimens, are generally numerous in the skeletons of mammals.

As regards the interpretation of bone frequencies it is important to point out that missing elements in the identified bone remains have at times been found in the particular bone material, which constitutes bone artefacts. For example, the metapodials of roe deer, the front legs and even one metatarsal of mountain hare were used in this way (Table 76).

Whether, during the Middle Neolithic in Sweden, man had different meat preferences to those of the modern Swedish population is difficult to establish. All one can say is that all the animals discussed would provide suitable meat for consumption. The difficulty of applying our conception of what is edible meat to an interpretation of the eating habits of prehistoric man has been discussed by Lyman (1979, p 537).

Taking meat producing animals into consideration the dog has deliberately been left aside. Only three dog specimens have been identified (Fig. 17), and these may all have come from a puppy. There are no distinct butchering marks, signifying evidence of kynophagy, the consumption of dog. It may be pointed out that Degerbøl (1939, p 169) suggests that Middle Neolithic people in Denmark, in contrast to Mesolithic groups, did not seem to have eaten meat or, for instance, brain of dog. It may, however, also be pointed out that kynophagy obviously existed in Europe during the Bronze Age, Iron Age and Early Middle Ages (Duerst 1904, p 264, Boessneck et al. 1971, p 92, 107, Boessneck & von den Driesch 1979, p 395) and that it still exists today in China for example.

As regards the proportions of unburnt, damaged by fire and burnt material it can be noted that pig is the only species from which the main part of the remains, about 60 %, consists of burnt fragments. Sheep is the species which has the biggest amount of fragments only damaged by fire, about 30 %. About one third of the fragments identified as red deer is burnt, while cattle has a very small part of specimens damaged by fire and burnt and the main part, 85 % or more, unburnt. The remains of dog, brown bear, badger, beaver and mountain hare consist only of unburnt specimens (Table 27).

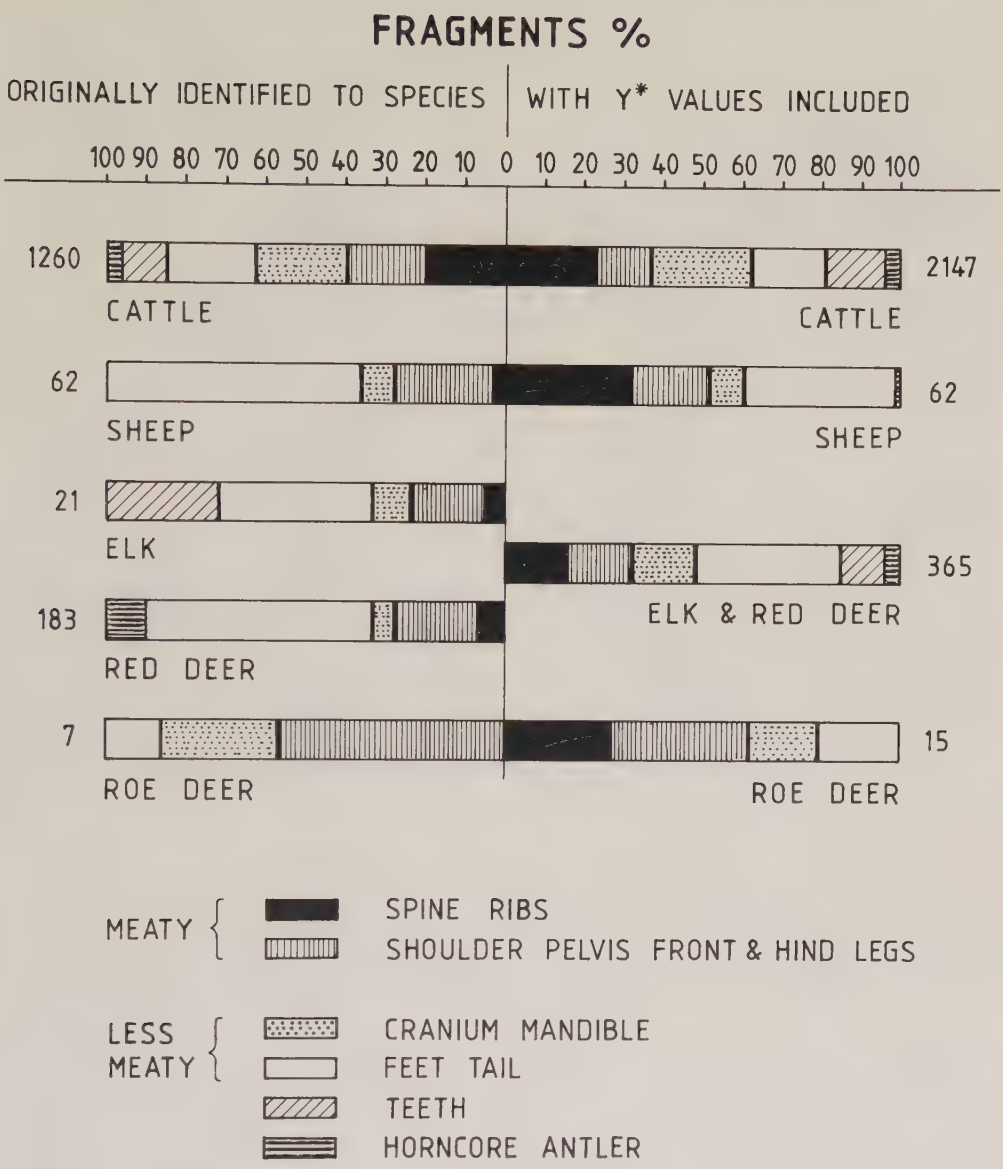

Fig. 16. Frequencies of different skeletal regions of CATTLE, SHEEP, ELK, RED DEER and ROE DEER given in % of the number of fragments originally identified to species, and together with frequencies including the fragments allocated to species using y values from the statistical evaluations.*

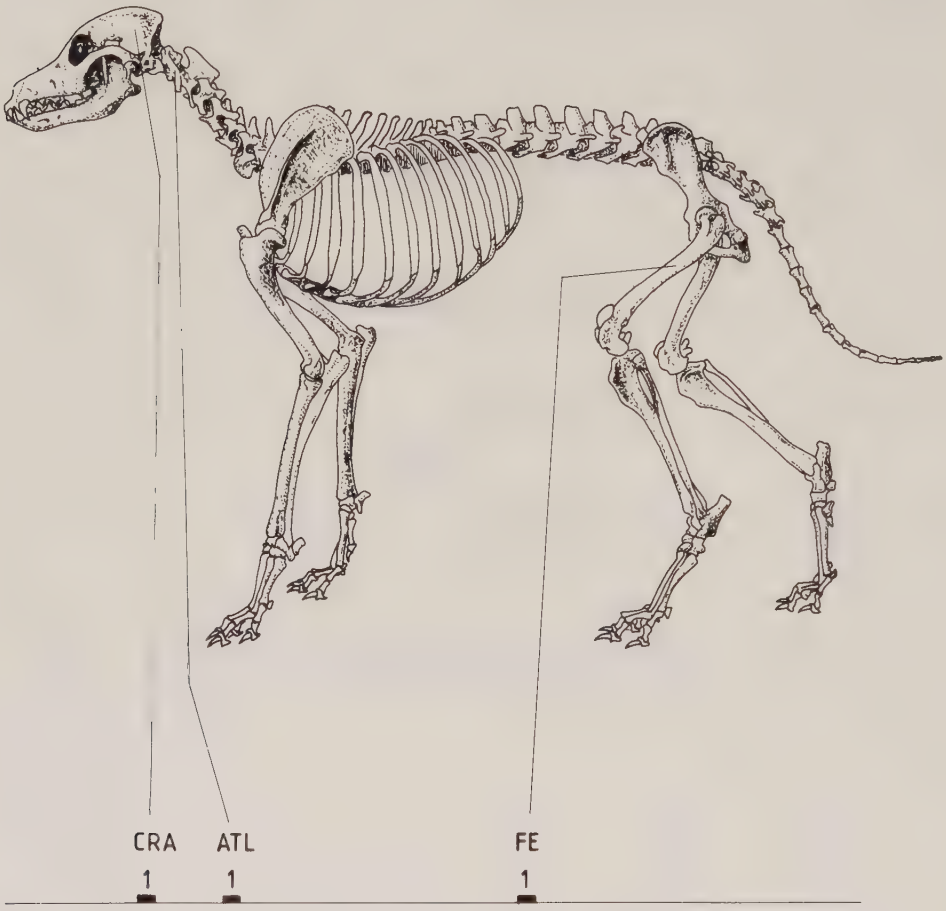

Fig. 17. DOG (3 fragm; 1.2 g). ATL = Atlas, CRA = Cranium, FE = Femur. (Redrawn after Nickel et al. 1961).

6.2 Non-meat producing mammals

6.2.1 Wolf (Canis lupus) Table 25

The frequency of specimens of wolf is low in the material, only 0.1 % by number and by weight (Table 29). One specimen of mandible is possibly identifiable as wolf. The rest, five fragments, come from the postcranial skeleton. One comes from the hind leg, a fibula fragment. The other four bones, all metacarpal specimens, may all come from the same forepaw. One whole metacarpal has thus been put together of fragments coming from adjacent squares and levels in the trench. Hence there are specimens from both the front and hind part of the body and possibly also from the jaw (Table 30).

6.2.2 Pine marten (Martes martes) Table 25

There are fragments from all body regions present in the material. Some bone types are missing, for example the carpal bones and the distal phalanges. The 30 teeth represent more than 25 % of the material and are by far most common skeletal specimen. Together cranium and mandible account for a little less than 20 %, the same percentage as the paws and tail. The rest, less than 40 %, comes from spine, ribs, shoulder and front leg (more than 25 %), pelvis and hind leg (more than 10 %) (Table 30). Pine marten accounts for about 2.6 % of identified bones, although only about 0.2 % by weight (Table 29). With respect to number of fragments and individuals the pine marten seems to be the most common species among the fur animals.

6.2.3 Lynx (Lynx lynx) Table 25

The frequency of lynx is low in the material. Only two fragments are identified, one unfused epiphysis of a metacarpal and a fragment of radius, representing a forepaw and a forelimb (Table 30).

6.2.4 Wild cat (Felis silvestris) Fig. 18

Most skeletal regions are represented in the material, mostly with single specimens. However, some bone types are totally missing as, for instance, the upper arm, carpal bones, pelvis, femur, tarsal bones and caudal vertebrae. Cranium, mandible and teeth account together for 50 % of the remains. Metapodials and one phalanx account for about 10 % and represent the paws. The rest, about 40 %, consists of single elements from vertebrae, costa, scapula, forearms and lower hind legs representing the spinal column, ribs, shoulder, front leg (more than 25 %) and hind leg (more than 10 %) (Table 30). In the whole of the material identified to species wild cat represents about 0.6 % by number, about 0.1 % by weight (Table 29).

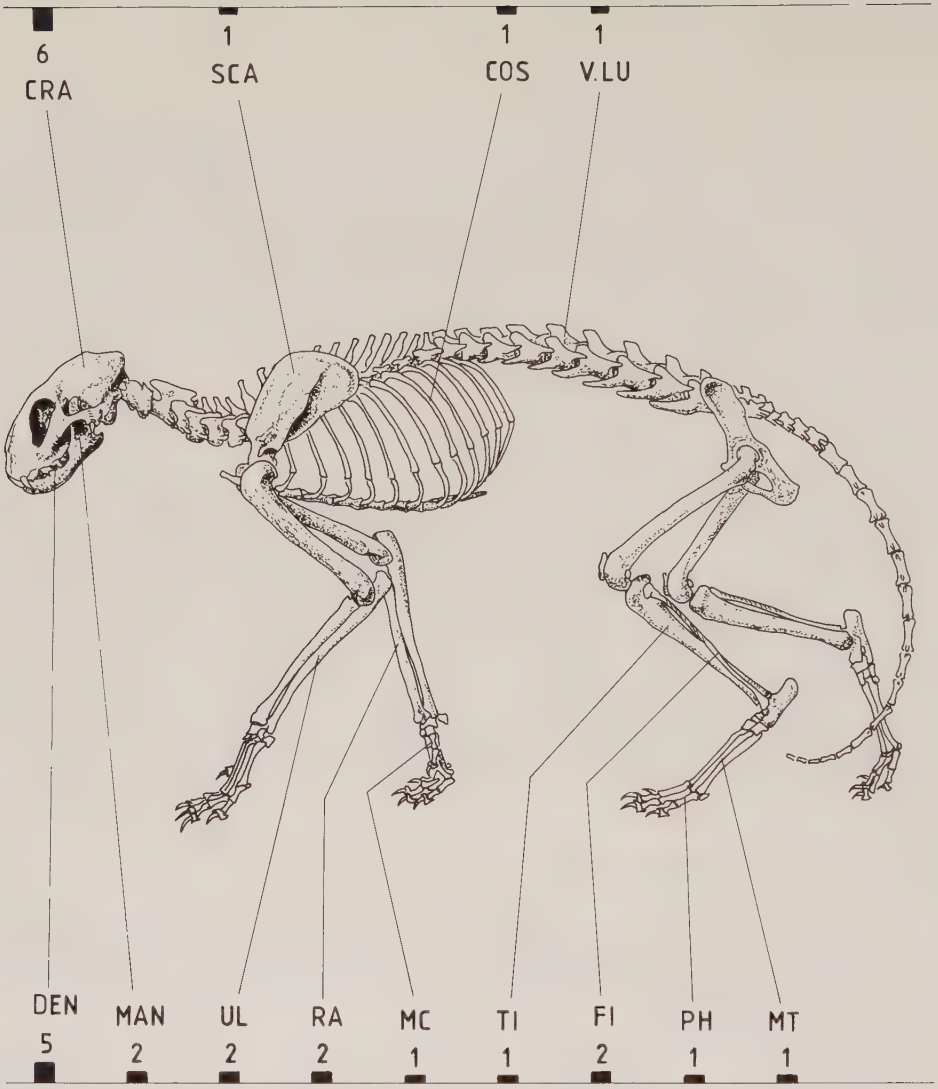

Fig. 18. WILD CAT (26 fragm; 11.2 g). CRA = Cranium, COS = Costa, DEN = Dentes, FI = Fibula, MAN = Mandibula, MC = Metacarpale, MT = Metatarsale, PH = Phalanx, RA = Radius, SCA = Scapula, TI = Tibia, UL = Ulna, V lu = Vert. lumbalis. (Redrawn after Nickel et al. 1961).

6.2.5 Summary and comments

The presumed non-meat producing mammals, wolf, pine marten, lynx and wild cat, may all be considered as mainly providing skins and furs, which probably also had economic value and thus were attractive to man. As regards potential pelt producers both the brown bear, badger, beaver and mountain hare have also to be considered (Chapter 7).

The representation of bone elements from various body regions indicates that whole bodies of pine marten and wild cat have been brought to the pile dwelling.

Wolf and lynx are represented only by single bone specimens and this is for instance also the case for the brown bear and the beaver. The reason for this may more likely be of a stochastic nature than a clear indication that only certain parts of these animals were brought to the site even if this can not be excluded.

There is of course also the possibility that meat from some of these animals had also been consumed. It has been pointed out that roast from a lynx looks like and tastes very much like meat from fatted calf (Lloyd 1855, p 4, Ekman 1910, p 122) or turkey (Lieberkind 1939a, p 116) and that Laplanders have in the past eaten lynx but not, as far as known, wolf meat (Bjärvall, pers. comm.). Moreover, the meat of lynx seems to have been quite appreciated as food among Swedes at least since the 18th century (Bergius 1787, p 64). It has further been pointed out that, formerly, in the 19th century, women were not allowed to eat meat from beasts of prey at all, with one exception, the 'white' meat of lynx (Jonsson, pers. comm.). In view of this it has to be recognized that food taboos could have occurred, as well as customs demanding consumption of meat and offal from certain animals which, today, are considered neither appetizing nor edible.

Concerning the frequency of different bone types it is important to point out that as in the meat producing animals, bone elements (which are not represented in these remains of non-meat producing mammals) have been found in that part of the bone material which have also been used to manufacture bone implements etc. As example several long bones from wild cat can be mentioned (Section 7.1.19, Table 76).

As regards the proportions of unburnt, damaged by fire or burnt material it can be noted that wolf is the only species which is not represented by any unburnt fragments. The main part of the remains of pine marten and wild cat, about 85 % and 90 % respectively, consists of unburnt specimens (Table 29).

6.3 Birds

The identified bird remains consist of unburnt specimens with one exception, a wing bone, which is damaged by fire.

6.3.1 Crane (Grus grus) Table 19

In the identified bone material 4.3 g and 2 fragments are identified as crane. The fragments consist of a proximal part of a left humerus and an outermost phalanx of a right wing, a digit II. Both remains represent thus the wings, one coming from a more meaty and the other from a less meaty part.

6.3.2 Heron (Ardea cinerea) Table 19

There are 0.2 g and one fragment identified as heron in the material. The bone specimen is from a furculum, and as part of the bird's shoulder girdle, represents a meaty region.

6.3.3 Capercaillie (*Tetrao urogallus*) Table 19

There are 0.3 g and one fragment identified as capercaillie in the material. The bone specimen comes from a furculum, belonging to the individual's shoulder girdle, a meaty body region.

6.3.4 Teal (*Anas crecca*) Table 19

In the identified bone material 0.2 g and one fragment have been identified as teal. The bone specimen consists of an intact left coracoid, and as part of the shoulder girdle thus comes from a meaty body part. The coracoid is considered to be one of the most resistant elements of a duck skeleton (Lepiksaar 1982, p 124–125).

6.3.5 Wild duck species (*Anatidae* species) Table 19

There are 0.9 g and 2 fragments which can be possibly related to this major taxonomic group. The remains consist of one specimen from a breastbone (*sternum*) and one specimen from a wing bone (*carpometacarpus*), thus forming parts of both meaty and less meaty skeletal areas.

6.3.6 Wood pigeon (*Columba palumbus*) Table 19

One fragment, 0.2 g, has been identified as wood pigeon among the bone remains. The specimen consists of a practically intact left scapula, and as part of the shoulder girdle thus comes from a meaty region of the bird skeleton.

6.3.7 Meadow pipit (*Anthus pratensis*) Table 19

The bone specimen identified as meadow pipit consists of one intact left ulna, 0.1 g by weight. Anatomically this is a bone type coming from the wing.

6.3.8 Tree pipit (*Anthus trivialis*) Table 19

The bone specimen identified as tree pipit consists of one distal part of a lower left hind leg (*tibiotarsus*), with a weight of 0.3 g. Generally this is considered to be a resistant bone type of the bird skeleton (Lepiksaar 1982, p 124–125).

6.3.9 Meadow pipit or Tree pipit (*Anthus pratensis or trivialis*) Table 19

In the identified animal bone material there is further 0.1 g, one fragment, which could not be identified to one of the pipit species in particular. The specimen consists of an almost intact left humerus, thus forming a part of the wing.

6.4 Fish

The main part of the identified fish bones, about 96 %, consists of unburnt fragments, about 3.5 % of the remains are burnt and about 0.5 % damaged by fire.

6.4.1 Pike (Esox lucius) Table 20

In the identified fish remains from the Eastern Trench, 40.1 g (56 %) representing 102 fragments (29 %) are identified as pike. Pike, together with bream, is the most common species in the fish material. Bone elements from most skeletal regions are identified. 53 % by number of the remains consists of specimens of teeth, mandible (*dentale*) and bodies of vertebrae from trunk and tail. Remaining specimens of jaws and other skull fragments represent about 24 %. The rest of the material, about 23 %, consists of elements from the gill-covers, shoulder girdle, pelvis, hemal arches and gill arches (*branchialia*) and the fins. About 91 % of the fragments are unburnt, 2 % are damaged by fire and 7 % are burnt.

6.4.2 Perch (Perca fluviatilis) Table 20

In the identified fish bones there are 4.3 g (6 %) and 47 fragments (13 %) from perch. There are bone types present from rather many body regions. The main part of the remains, 34 % by number, comes however from scales. Different parts of the jaw apparatus represent 17 %, and 17 % comes also from vertebrae of trunk and tail. The rest, a little more than 30 %, consists of other elements from the skull and also shoulder girdle, gill-covers and fins. Two of the vertebral specimens are burnt.

6.4.3 Whitefish (Coregonus species) Table 20

There are 4.6 g (6.5 %) and 41 fragments (12 %) identified as whitefish in the identified fish bone material. The main part, about 93 % by number, comes from vertebral specimens from trunk and tail. The rest consists of separate specimens of the jaw apparatus and shoulder girdle.

6.4.4 Bream (Abramis brama) Table 20

There are 16.0 g (22 %) and 92 fragments (26 %) identified as bream in the identified fish bone material. This means that the bream, as well as the pike, is a relatively common fish in the material. The main part, 96 % by number, of the remains comes from bodies of vertebrae from trunk and tail. The rest, 4 %, consists of separate specimens of the skull, ribs and gill-covers.

By the statistical evaluations 20 g (28 %) and 139 fragments (39 %) are allocated to bream (Section 5.4), making the bream more frequent than the pike in the material (as regards the number of fragments). The allocation of 'grouped material' from the 'carp family' (Table 20) also means that the skeletal distribution of elements from body regions is changed to some extent, giving about 83 % to vertebral bodies and 17 % to skull, ribs, gill-covers, pharyngobranchial bones and scales.

Among the remains only two elements are burnt, both vertebral specimens.

6.4.5 Tench (Tinca tinca) Table 20

There are 0.4 g and 4 fragments (1 %) identified as tench in the identified fish bone material. Three specimens are vertebrae from the tail and one is an element (*basipterygoideum*) from the cranium.

6.4.6 Roach (Rutilus rutilus) Table 20

In the identified fish bone material 0.5 g (0.7 %) and 5 fragments (1.4 %) are identified as roach. Three of the bone specimens come from vertebrae belonging to trunk and tail. Two are pharyngobranchial bones.

6.4.7 Rudd (Scardinius erythrophthalmus) Table 20

In the identified fish bone material 0.5 g (0.7 %) and 5 fragments (1.4 %) have been identified as rudd. One specimen comes from a vertebrae belonging to the tail. Four specimens are pharyngobranchial bones.

6.4.8 Ide (Leuciscus idus) Table 20

There are only 0.2 g and one fragment identified as ide in the identified fish bone material. The specimen consists of one pharyngobranchial bone.

6.4.9 Carp family (Cyprenidae) Table 20

Among the identified fish bone remains 4.6 g (21 %) and 55 fragments (34 %) can only be allocated to a major taxonomic group named the carp family. The main part, 60 % by number, are vertebral specimens from the trunk and tail. About 25 % comes from ribs and scales. The rest, about 15 %, comes from skull and gill-covers. Two of the vertebral fragments are burnt. By the statistical evaluations 47 of the fragments (85 %) and 4 g have been allocated to bream and the rest (15 %) to a major taxonomic group which, tentatively, comprises tench, roach, rudd and ide (Section 5.4).

Generally the carp family consists of many different species, anatomically fairly similar (Lepiksaar 1977, p 56). The carp fishes have no real teeth and work the food with the pharyngobranchial bones. These specimens are also called the 'carp teeth' (Muus & Dahlström 1981, p 19). These are, morphologically, characteristic for each species. In the actual material they have been very useful in the identification of different species.

To sum up, the remains of carp fishes represent totally 22.2 g (31 %) and 162 fragments (46 %) of the identified fish bone material from the Eastern Trench. Of these remains 17.6 g (79 %) and 107 fragments (66 %) were distributed among particular species. Referring to the statistical evaluation 100 % have been more closely identified to species, that is 20 g and 139 fragments to bream and 2.2 g and 23 fragments to the presumed major taxonomic group comprising tench, roach, rudd and ide.

7. Economy – Biotope

The species which have been identified in the bone material provide valuable information of the vertebrate fauna existing at the time of the Alvastra pile dwelling and help to show how the Middle Neolithic people made use of the surrounding natural resources. Qualitatively the animal bone sample from the Eastern Trench gives valuable zoological, biological and ecological informations. In the following pages an attempt is made to analyse in what respect the vertebrate species represented in the material may have had importance for human life and economy. The ecological system and the different biotopes present in the environment both in the vicinity and further away from the pile dwelling are discussed in accordance with the vegetational history of the area. Each identified species and its preferences and needs are taken into consideration. In this respect the social behaviour among the different species has also to some extent been considered. The relative frequency among species, the question of castration, carcass weight and the probable seasons of slaughter, hunting and fishing are discussed in view of their assumed importance for the human economy and so is also the question of seasonal use of the site. The possible occurrence of the remains of aurochs and of pigs, the latter in an early stage of domestication, are investigated.

It is already established (Section 1.3) that species identified in an archaelogical bone sample which probably consists of food debris to a considerable extent also reflects a human choice. It should be noted that there may of course have existed other species in the locality of the pile dwelling than the ones identified in the bone material from the site. Moreover, various taphonomic and other reasons than just the sample size for the heterogeneous distribution of skeletal remains represented in the bone material will be discussed in this part of the study and especially in Section 7.1.4 which concerns the red deer.

The results achieved are also compared with and tested against earlier and unpublished analyses of bone material from the pile dwelling (Pira 1909, Hedell 1910–1913, 1919, Ekman 1977). Analyses of bone samples from other archaelogical sites are also used, in particular as regards measurements (Tables 33–75) and in order to study differences and similarities.

Furthermore, the presence of marks from butchering, gnaw marks, pathological and other changes noted on the bone specimens is commented upon and finally, investigations have been made as regards the fauna and biotopes existing in the localities today in order to discover variations and changes.

7.1 Mammals

The mammals account for about 90 % of the number of fragments and 99.5 % by weight of the identified animal bone material. The number of fragments of mammals identified in previously undertaken analyses are shown in Table 31.

7.1.1 Cattle (Bos primigenius f. taurus)

According to the vegetational history of the area around Alvastra pile dwelling (Göransson 1982a, 1982b, 1986) the prevailing environmental conditions were

favourable for animal husbandry in Middle Neolithic time. Göransson suggests that this occupation was an important form of livelihood and that the landscape in the Alvastra area was clearly influenced by man and his livestock. This included an exploitation of the forest of various kinds. The establishment of coppice wood and creation of grass sward is probable. In the surrounding region there were areas suitable for cultivation, such as the light lime-rich soils in the Isberga district and also light soils in the Smörkullen region. The most common trees were elm, lime, oak and also ash and hazel. In the coppice woods the livestock could graze leaves, twigs, sprout and also grass. In addition coppice woods were sometimes transformed into pruned woods. In these pruned woods the livestock could not reach the sprouting twigs which could later be collected as winter fodder. Man controlled the coppice wood by cutting down certain branches, twigs and young stems. He also cleared parts of it totally to cultivate cereals. Göransson further suggests that some cut slender stems were used as fences to protect the small arable plots. A large part of the resource area consisted of fen land, such as the vast fen area situated between Alvastra Spring Mire and the bog *Dags mosse* and the low, moist shore fens of Lake Tåkern. In these parts high sedge plants (*Carex species)* and reed (*Phragmites species)* grew and flourished, constituing very important grazing, where the livestock could consume young plants and grasses during early summer time. Furthermore, it may be pointed out that the borders of fens and shores, where alder, sallow and scrubs thrived constituted important pasture. Göransson claims that probably also alder wood growing on the wet soils were usefully transformed to coppice woods. All these areas had given an abundant amount of fodder. It can be assumed that in some parts the livestock was at times kept fenced in or maybe tethered or tended by shepherds. This could have been done to protect areas from being too severely grazed, to facilitate a rotation system for cereal growing on the light earths and to protect growing crops. The livestock may also have needed protection from being attacked by predatory animals such as brown bear, wolf and lynx existing in the area.

There are no bone specimens positively identified to aurochs *(Bos primigenius)* in the bone material from the Eastern Trench. The distinction between wild and domestic cattle in bone samples from Neolithic times is usually based on size differences. Among aurochs there is a pronounced sexual dimorphism with one exception. In aurochs cows the teeth are comparatively large (Degerbøl & Fredskild 1970). This means that the size of small wild females and large domestic males may coincide. This creates difficulties in identification. Van Wijngarden-Bakker (1980, p 112) points out that the measurements of aurochs also show distinct geographical variation. In addition transitional forms due to local domestication may be another source of error (Bökönyi 1974).

In his analysis of bone material from the excavation in 1919 of the pile dwelling Hedell suggests that some bone specimens, such as phalanges, may have belonged to aurochs in view of the measurements, general size and morphology. He identifies, however, in his analysis of bone material from 1913 phalanges as belonging to domestic cattle, using the same criteria (Hedell 1913, 1919). Hence the argument for aurochs specimens in these materials is less convincing.

In order to make it possible to compare measurements of bone specimens from

Table 31. Number of fragments (n) of **Mammals** occurring in bone material from the excavations of the pile dwelling in 1909–1911, 1912, 1913 and 1919, earlier analysed by A. Pira (1910), L. Hedell (unpublished bone lists) and J. Ekman (1977, unpublished bone list). Most frequent (mf), frequent (f), rather frequent (rf) and a few (af).

	Pira	Hedell					Ekman	
	1909	1910	1911	1912	1913	1919		**Total**
Species	n	n	n	n	n	n	n	n
Cattle	f	mf	mf	mf	mf	268	159	–
Aurochs	–	–	–	–	–	43	–	–
Sheep	–	7	af	>20	16	3	22	–
Goat	–	–	?	–	–	–	–	–
Sheep/Goat	9	1	–	–	–	–	–	–
Elk	af	13	af	12	5	1	11	–
Red deer	3	rf	f	rf	rf	418	290	–
Roe deer	7	rf	rf	>15	3	157	32	–
Wild boar and Domestic pig?	f	f	f	f	f	1089	–	–
Wild boar	–	–	–	–	–	–	154	–
Domestic pig	–	–	–	–	–	–	1	–
Wolf	3	10	12	–	1	3	1?	29/30
Dog	2	1	1	5	7	1	4	21
Brown bear	2	25	23	1	–	5	20	76
Badger	17	47	68	18	16	43	99	308
Pine marten	2	18	30	12	2	5	26	95
Otter	–	9	5	1	–	–	1	16
Lynx	–	4	4	3	2	6	9	28
Wild cat	–	8	11	22	–	17	27	85
Beaver	–	3	7	>6	4	1	9	>30
Mountain hare	6	7	11	1	–	–	2	27
Ground vole	–	6	3	1	–	1	2	13
Hedgehog	–	4	5	–	–	–	3	12
Red squirrel	–	–	–	–	–	1	–	1
Total	–	–	–	–	–	2062	872	

the pile dwelling with those of aurochs, available measurements from the very small urus female from Slågarp (Ekman 1972) are shown in Tables 33, 34, 36, 39–46. The results indicate that all measurements except those on one distal metatarsal and some of the phalanges (Tables 43–46) are clearly separated from the aurochs, and show lower values than the small urus female. Since with respect to measurements of several skeletal parts a large overlapping has been established between domestic male cattle and aurochs cows (Degerbøl 1970, Figs. 8–25), it is here claimed that the specimens in question may have belonged to a large sized animal, a bull or possibly a bullock or an ox. It is of course possible that the aurochs was still present in Östergötland and in the region of the pile dwelling. On the west coast of Sweden one find of aurochs has been made which C 14-analysis dates to 3940 ± 60 B.P. (LU 1260) (Lepiksaar 1983, p 147). However, the vegetational history of this area indicates that man had influenced the locality too much for the survival of at least herds of aurochs. Lepiksaar (1977b, p 88, 1983,

p 147) and Liljegren (1983, p 31) both claim that the aurochs probably preferred open grassfields and meadows near banks and shores. It has been questioned whether the aurochs was still present in the south of Sweden during Neolithic times (Liljegren 1983). With the appearance of the great and dense forests of oak, elm and lime during the Atlantic period, and the associated decrease in ground, light and grass, the open grassfields and wet grounds diminished. Consequently, there was far less pasture for the aurochs. Thus Liljegren suggests that a combination of changes in the environment and also hunting by man may have caused the extinction of most of the aurochs stock before Neolithic times. It has also been suggested (Lepiksaar 1982, p 106) that the Swedish stock of aurochs became isolated after the appearance of Öresund and that this prevented a population intrusion from the continent with accompanying regeneration of the local stock. Lepiksaar further suggests that this could have made the stock more vulnerable to hunting by man and other large predators such as the brown bear and the wolf.

The cattle remains from the Eastern Trench provide no direct evidence that castration has been practised. Whether castration had taken place among Neolithic cattle has been discussed in several studies. It has been suggested that there seems to be no definite evidence of castration as yet in the Neolithic cattle of northern Europe (Grigson 1982b). Others (Higham & Message 1969, p 325) conclude that a majority of the males from the Middle Neolithic settlement of Troldebjerg are castrates. Some arguments may, however, be put forward which speaks for, not against, use of castration. It has been pointed out that the carcass composition is strongly affected by castration, that is, the carcass of oxen is considerable fatter than that of bulls (van Wijngarden-Bakker 1980, p 121). A large proportion of male cattle in a sample of material may best be explained by a breeding system not for reproductive purposes in females but aiming at meat production, and since steers give a better meat, castration may have been practised. In communities with a system of extensive feeding and grazing of steers/bullocks their more peaceful temperament makes them more suitable to keep than bulls. This is also the case if males are used as draught oxen. Van-Wijngarden (1980, p 122) also states another argument which speaks in favour of castration. She emphasizes that it seems to be a fact that among steers the growth rate is reduced by an average of 10 %. Accordingly steers need a longer time to get an optimal and favourable carcass weight. Hence, if in a bone sample slaughtering seems to have taken place at a relatively advanced age (which was the case for the Newgrange cattle), this is compatible with a reduced growth rate and may speak for castration.

Among the cattle remains from the Eastern Trench there is, according to the measurements, no female identified among five, all possibly fully grown, individuals and one subadult individual. There are, though, indications of two or possibly three bulls (Table 10). In general the proportion of one male to ten females would be sufficient for the reproductive needs of the group (van Wijngarden-Bakker 1980, p 122). Presuming that castration has taken place during Neolithic times it was probably performed, for practical reasons, on young individuals.

Generally, in order to quantify by weight the remains of cattle with respect to their importance as a primarily meat producing mammal, live weight, carcass weight and bone weight have to be considered. It should be noted that the live weight depends on geographic and nutritional variation, age, sex and season. It is established that cattle are represented by bone specimens from all body regions in the material being studied, indicating that bodies of whole animals (cut up or not) were brought to the site. Using data from Boessneck et al. (1971, p 7–9) and van Wijngarden-Bakker (1980, p 115–116) an attempt has been made to estimate a probable live weight for the cattle to vary from 250 to 400 kg. The carcass weight for these cattle is calculated, by using the same data, to be 45–55 % of the live weight. The relative weight of the carcass compared with the live weight is denoted 'dressing percentage'. In relation to the live weight the bone weight is considered to be about 7 % and in the relation to carcass weight about 14 %. The rest of the carcass, 86 %, consists of fat and meat. The offal, removed from the body in the butchering process, consists of the head and feet (about 15 %), skin (about 20 %), internal organs (about 25 %) and contents of intestines and stomach (about 40 %). This means that at least one fourth, and probably more considering the edible bone marrow etc., can be added to the carcass meat and fat weight from the offal weight. In Table 32 calculations of edible portions have been made, assuming different live weights of 250, 300, 350 and 400 kg and with a dressing percentage assumed to be between 45 and 55 %.

Table 32. Estimation of the total **Edible portion** in kg for cattle. (Inspired by van Wijngarden-Bakker 1980, p 116, Table 3.3.4.)

	Dressing percentage 45 %				**Dressing percentage** 55 %			
Live weight	250	300	350	400	250	300	350	400
Carcass weight	113	135	157	180	138	165	192	220
Muscles + fat	97	116	135	155	118	142	165	189
Edible organs	35	41	48	55	28	34	40	45
Total Edible portion	132	157	183	210	146	176	205	234

The results of the estimations show that the edible portion for cattle varies between 50 and 60 %, that is about 130–165 kg for a live weight of 250 and 400 kg respectively. It has been suggested (Boessneck et al. 1971, p 8) that the human gain was probably more, in fact up to four fifths (80 %) of the live weight, since blood, brain, meat and marrow from cranium and mandible are also protein foods. Considering the measurements of different bone elements from the Eastern Trench (Tables 33–46), one can say that the variation in size indicates the presence of both rather small and large adult animals. The calculations of withers height to between 114 and 140 cm (Tables 47 and 48) by measurements given in earlier unpublished analyses (Table 43), as well as other dimensions given in these analyses (Tables 33–46), indicate the same variation for cattle remains from other

parts of the pile dwelling. It has been pointed out (van Wijngarden-Bakker 1980, p 116–117) that there is a relation between mature body weight and the growth time it takes to reach it, and that among primitive late-maturing breeds the growth rate is slower but that they attain greater ultimate size and weight. Proportions of the body change during growth and the main tissue – bone, muscle and fat – develop in a certain order, that is, bone earlier than muscle and muscle earlier than fat. During growth more fat is proportionally added to the carcass, deposited between muscles and bundles of muscle fibres, rather than to the offal parts. This means that slaughter of mature animals with probably heavier weight brings with it a higher proportion of fat in the carcass. It has been shown by experiments that when the dressing percentage increases from 50 to 60 % the percentage of fat in the carcass increases three-fold (Hammond et al. 1971). In this connection it may be important to state that the weight and growth pattern among these animals is to a high degree dependent on the conditions of life, pasture, food and fodder supply etc. for the population in question. Malnutrition, epidemic diseases and other illness may of course affect the pattern. When comparing this data on carcass weight with modern Swedish ones it can be noted that now the best beef is considered to come from animals between one and 1.5 years old with a live weight of about 400–600 kg and a carcass weight between 200 and 300 kg (Slakteriorganisationen 1982).

On the basis of related facts and results it can be concluded that animal husbandry was probably of great importance for the life and economy of the Middle Neolithic people who used the pile dwelling. The remains of *Bos* show that this species was one of their best meat producers, probably the best, and a main source of protein. This assumption is supported by the results presented in the vegetational history of the area around the site and also by results of earlier, published and unpublished, analyses of bone material from the pile dwelling. In the material from the excavations in 1909–1913 *Bos* is the most common species. It is also rather frequent in the other analyses (Table 31). It is further demonstrated in analyses of bone material from Danish Middle Neolithic sites (for example Bundsø and Lidsø) that cattle remains were the most common ones (Degerbøl 1939, p 88, 133, Hatting 1978, p 200–201). Considering the size it can be assumed that some of the animals may have been very large, attaining an estimated withers height of about 140 cm (Tables 47 and 48). This amounts to several present-day improved races. It should be noted that the measurable bones are few but that the estimations of withers height has a wide range (114–140 cm). The individual measurements of different bone specimens are well in agreement with measurements available from other Neolithic sites (Tables 33–46). It has been pointed out that Danish domestic cattle of Neolithic date were of a large size even if, in general, the size had decreased compared to the wild progenitor, the *Urus*. It is further stated that quite large variation in size existed (Winge 1900, p 146, 1908, p 191, Degerbøl 1939, p 195, 1963, Hatting 1978). In terms of size and measurements of the bone elements in general, the Alvastra cattle agree with cattle remains from other Neolithic European sites. These remains are also considered to have come from large animals (Nobis 1954, Degerbøl 1963, p 74, van Wijngarden-Bakker

1980, p 117). Furthermore it is stated in some analyses (Degerbøl 1939, Degerbøl & Fredskild 1970, Hatting 1978) that no domestication of local *Urus* stocks has taken place in Northern Europe. A human interference from time to time is, however, not excluded (Hatting 1978, p 201).

From the Neolithic to the Bronze Age there was a distinct decline in size of domestic cattle in Denmark (Degerbøl 1963, p 74–75). Hence, in comparison with domestic animals from all later prehistoric periods as well as from the Middle Ages, the Neolithic cattle are large animals (Tables 33–46).

Ageing and sexing data (Section 4.1.1) indicate that cattle were kept for both meat and milk production, possibly other dairy produces and for reproductive purposes. Fourty or possibly fifty percentage of the animals were skeletally fully grown individuals when slaughtered. It is likely that some were killed as younger adults, about 4 years old, having probably attained a good carcass weight with respect of being from a primitive late-maturing stock. Access to food and fodder was probably very good for the livestock (Göransson 1986). This could have meant that juvenile animals (younger than 2.5 years) also attained an acceptable carcass weight before they were fully grown. In connection with the interpretation of these remains it should, however, be stressed that cultural factors may have existed which influenced the killing of animals for reasons other than simply for food consuming.

According to data from van Wijngarden-Bakker (1980, p 131) the heifers probably had their first calf in the spring, at about 3 years of age. She also mentions the possibility that the heifers could have had their first calf in the autumn at about 2.5 years of age. This is, however, unlikely in view of these mammals' general pattern with birth taking place in spring and should mean that heifers at about 2.5 years of age also had calves in spring or had their calves in autumn at about 3 years of age. In addition calves born during spring had probably better possibilities to survive than those born during late autumn.

In the Eastern Trench material there are also indications of individuals older than 6 years. These remains may come from cows kept for milk production and selected to reproduce. With respect to slaughter it is assumed that late autumn was the season when slaughter was most convenient. This was the time of year when the meat was best after the fattening spring and summer pasture. This was also the time of year when conditions were most suitable for drying, smoking and storing the meat (Boessneck & von den Driesch 1979, p 65, Gejvall 1981, p 116).

Among the remains of cattle from the Eastern Trench only two juvenile animals could be more closely age determined, one between 1 year and 1.5 years old, the other between 1 year and 2.5 years old. This is some indication that the people who used the pile dwelling practised slaughter in the fall.

To sum up, the carcass of cattle may have been used by prehistoric man in various domains. In addition to consuming meat, that is, everything edible, the hides could have been used as clothing and the fat for tallow. Some body parts, for instance the metapodial area, could have provided sinews useful in various sewing work. The feet of the wild ox have for example been called 'the hunter's sewing kit' (Perkins & Daly 1968, p 104). In the Alvastra material the metapodials have also

been used in manufacturing bone implements (Table 76). It may also be pointed out that the manure, when dried, could have been used as fuel. It can thus be concluded that, for man, domestic cattle were in many ways the most valuable resource animals of all. As an evidence of the importance of domestic cattle to man Clutton-Brock (1981, p 62) points out that prehistoric human societies often used both the bull and the cow as symbolic figures.

Only ten of the bone elements, one mandible part, two ribs, one metacarpal, one calcaneum and two phalanx fragments, show marks from cutting and butchering processes, for instance to have been fractured to extract the marrow (Table 77). It should, however, be noted that the degree of fragmentation is in general high in the material. This may to a great extent depend on the fracturing of the bones to get access not only to the bone marrow but also to the bone grease and juice (Bonnichsen 1973, Noe-Nygaard 1977, Binford 1978, 1981). Fracturing and fragmentation processes result in small fragments making it impossible to identify all fragments with distinct marks to bone type and species. The processes probably also result in many fragments with no distinct marks at all. Hence in the material examined, there are probably a lot of splinters from, for instance, long bones with no distinct marks from the butchering process or the implements used. In addition there are also fragments with distinct marks on them without the possibility to identify particular bone type or species (Table 4).

The remains of cattle have also been attractive to dogs and probably other scavenging animals. The main part, probably more than 40 pieces, of the identified bone material which shows marks of being gnawed and chewed by animal teeth, comes from cattle (Table 78). The fragments come from various skeletal regions. Such factors have of course also contributed to the fragmentation of the bone material.

One dental anomaly only was noted; a loose premolar (P_4) from an upper jaw shows an abnormal kind of severe attrition (Fig. 19). A distal part of one metacarpal shows slight degenerative changes at the joint (*trochlea*). There seems to have been some deposition of new bone, which has caused the joint change. The cause may well have been an antropathy of non-infectious degenerative origin

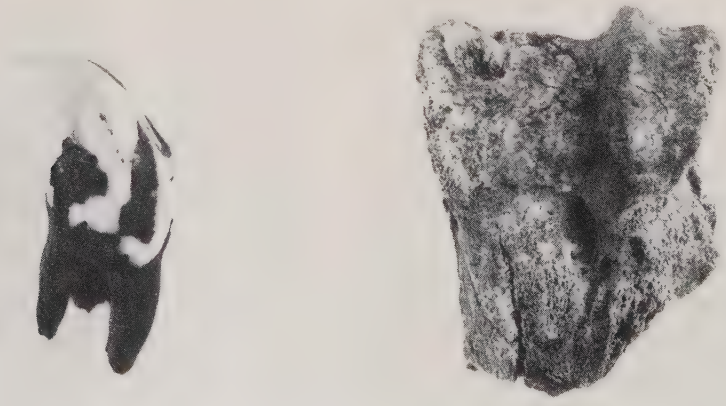

Fig. 19. CATTLE. 1. P^4 showing an abnormal kind of severe attrition. 2. METACARPAL showing slight degenerative changes at the joint. Scale 1:1.

(Siegel 1973, p 361–362), an osteoarthritis (Baker & Brothwell 1980, p 114–115). Both these changes are said to usually originate from a constant pressure or trauma on the joint. This accelerates the normal process of ageing and seem to be particular common in the feet of cattle (Siegel 1973, Baker & Brothwell 1980). It has been argued that severe attrition of teeth and pathological changes in the joints of the foot bones may be signs of aged animals or training of steers to become draught oxen, and thus indicate that castration has been practised (van Wijngarden-Bakker 1980, p 131).

Table 33. **Cattle.** Measurements of **Horn cores;** basal circumference (44), maximum (oro-aboral) diameter of the base (45), minimum (dorso-basal) diameter of the base (46) and index $\frac{(46)\times 100}{(45)}$. All index values (except 22) are calculated by the present author. Estimated values underlined. Sex female (♀). Data in mm.

Locality	Age	(44)	(45)	(46)	Index
1 Alvastra Eastern Trench	MN	122.0	46.7	31.1	66.6
2 Alvastra L. Hedell	MN	200.0 220.0	–	–	–
3 Alvastra J. Ekman	MN	210.0	71.0	60.8	85.6
4 Cave *Stora Förvar*	N (mainly)	124.0–140.0	42.0–49.0	35.0–40.0	
7 Bundsø	MN	130.0–210.0	46.0–80.0	39.0–60.0	
8 Lidsö	MN	135.0–240.0	54.0–85.0	43.0–68.0	
10 Aalborg	MN	–	62.0, 58.0	44.0, 45.0	70.9, 77.6
13 New Grange	LN	156.0, 164.0	57.0, 60.0	39.4, 42.5	69.0, 71.0
14 Hötofta	BA	147.0	51.0	42.5	83.3
16 Sorte Muld, Dalshøj	IA	–	38.0–84.0	30.0–58.0	
17 Vejleby	IA	–	48.0, 56.0	35.0, 36.0	72.9, 64.3
19 Eketorp II	400–700	110.0–147.5	37.3–50.5	31.0–41.7	–
20 Eketorp III	1000–1300	93.5–200.0	31.4–71.3	26.5–54.7	–
21 Lund	1020–1400	102.0–196.0	34.0–68.5	28.0–57.0	–
29 Slågarp (aurochs ♀)	EB	246.0	85.0	67.0	78.8

Table 34. **Cattle.** Measurements of **Teeth;** M^3 and M_3 maximum length (L) and breadth (B), length of M^1–M^3, length of the cheek tooth row, along the alveoli (21). Data in mm.

		M^3		M_3			
Locality	**Age**	**L**	**B**	**L**	**B**	**M^1–M^3**	**(21)**
1 Alvastra Eastern Trench	MN	28.4, 31.1	20.0, 22.3	35.5	14.0	83.5	–
2 Alvastra L. Hedell	MN	28.0, 28.4, 29.4, 35.0	–	36.2–38.0, 38.3, 40.0	–	–	85.0
3 Alvastra J. Ekman	MN	28.5, 30.9, 31.0, 31.5	–	36.5, 40.5, 40.5, 42.0	– 16.9	–	85.1
4 Cave *Stora Förvar* (mainly)	N	27.0–29.0	15.0–20.0	35.0–37.0	14.0–16.0	79.0	–
5a Troldebjerg	MN	–	–	32.3–45.0	–	–	–
6 Blandebjerg	MN	–	–	34.0–41.0	16.0–18.0		–
7 Bundsø	MN	29.0–31.5	21.0–24.5	37.5–39.5	16.0–17.5	82.0–87.0	–
8 Lidsø	MN	–	–	39.2, 40.5	18.0, 16.2	–	–
9 Ørum AA, **10 Aalborg**	MN	–	–	36.0–42.5	–	–	–
12 Aamosen	Mes-MN	27.3–33.5	22.3–24.0	35.0, 36.0	15.0, 14.7	–	–
13 New Grange	LN	–	–	33.3–46.3	12.5–19.4	–	–
15 Voldtofte, Hillerød	BA	–	–	32.0–41.0	–	–	–
16 Sorte Muld, Dalshøj	IA	26.0–31.5	20.0–25.0	31.0–38.0	–	–	–
17 Vejleby	IA	–	–	33.0–38.5	–	–	–
19 Eketorp II	400–700	–	–	31.1–36.6	–	–	–
20 Eketorp III	1000–1300	–	–	29.5–38.2	–	–	–
22 Slågarp (aurochs ♀)	EB	–	–	45.5	19.0	–	104.0

Table 35. **Cattle.** Measurements of **Teeth;** M^1, M_1, M^2 maximum length (L) and breadth (B). Data in mm.

Locality	Age	M^1 L	M^1 B	M_1 L	M_1 B	M^2 L	M^2 B
1 Alvastra Eastern Trench	MN	24.4, 28.9	19.6, 20.9	28.2 –	15.5 –	28.3 –	21.8 –
2 Alvastra L. Hedell	MN	27.3, 30.5	–	–	–	–	–
4 Cave *Stora Förvar*	N (mainly)	20.0– 25.0	17.0– 22.0	20.0– 28.0	11.0– 17.0	26.0– 28.0	16.0– 21.0
7 Bundsø	MN	25.0– 27.0	23.0– 24.0	23.5– 31.0	12.5– 16.5	28.0– 31.0	23.0– 25.0

Table 36. **Cattle.** Measurements of the **Axis;** max. breadth of the cranial articular surface (BFcr). Measurement of the **Pelvis:** length of acetabulum including the lip (LA). Data in mm.

Locality	Age	Axis BFcr	Pelvis LA
1 Alvastra Eastern Trench	MN	79.0	63.8
13 New Grange	LN	–	74.5– 77.5
19 Eketorp II	400– 700	69.3– 100.5	57.3– 66.9
20 Eketorp III	1000– 1300	72.7– 94.9	57.8– 75.8
22 Slågarp (aurochs ♀)	EB	–	80.5

Table 37. **Cattle.** Measurement of **Os malleolare (Os mall.),** the fibula; max. depth (GD). Measurement of **Os tarsi 2+3;** max. breadth (GB). Data in mm.

Locality	Age	Os mall GD	Os tarsi 2+3 GB
1 Alvastra Eastern Trench	MN	31.7, 35.0, 36.2	32.1
2 Alvastra L. Hedell	MN	29.5	35.0, 42.0

Table 38. **Cattle.** Measurements of the **Scapula;** min. length of the neck (SLC), max. length of the glenoid process (GLP), length of the glenoid cavity (LG) and breadth of the glenoid cavity (BG). Data in mm.

Locality	Age	SLC	GLP	LG	BG
1 Alvastra Eastern Trench	MN	–	70.1	59.1	52.6
2 Alvastra L. Hedell	MN	42.0, 48.0, 48.3, 53.2, 56.2	61.5, 56.7, 64.6	49.0, 52.8, 55.0, 62.0, 62.5	38.0, 45.7, 47.5, 56.0 57.0
3 Alvastra J. Ekman	MN	39.6, 40.7 46.3, 47.3, 51.0, 55.5	–	–	–
7 Bundsø	MN	45.0– 63.0	61.0– 77.0	52.0– 64.0	48.0– 63.0
8 Lidsø	MN	–	68.2	59.4	46.0
9 Ørum AA,	MN	69.0,	–	–	–
10 Aalborg		50.0	–	–	–
11 Leire AA		64.0, 59.0			
12 Aamosen	Mes- MN	54.0– 69.0	72.0	51.0	48.0
13 New Grange	LN	49.5– 70.5	–	41.0– 70.0	38.5– 58.5
14 Hötofta	BA	52.0, 53.0, 61.0	–	–	–
17 Vejleby	IA	45.0, 47.0, 51.0	–	–	–
19 Eketorp II	400– 700	39.4– 50.2	55.1– 71.6	–	–
20 Eketorp III	1000– 1300	38.7– 60.6	56.0– 80.2	–	–
21 Lund	1020– 1400	34.5– 58.0	–	–	–
23 Møen Bog (aurochs ♀)	–	88.0	–	–	–

Table 39. **Cattle.** Measurements of the **Humerus;** maximum breadth of the distal end (Bd) and maximum breadth of the trochlea (BT). Measurements of the **Ulna;** depth across the processus anconaeus (DPA). Data in mm.

		Humerus		Ulna
Locality	**Age**	**Bd**	**BT**	**DPA**
1 Alvastra Eastern Trench	MN	–	69.5, 71.2	55.6, 59.0, 59.0
2 Alvastra L. Hedell	MN	92.0	78.5	–
3 Alvastra J. Ekman	MN	84.5	66.5 75.1	–
4 Cave *Stora Förvar*	N (mainly)	68.0, 73.0 79.0	64.0– 71.0	–
6 Blandebjerg	MN	–	69.0– 85.0	–
7 Bundsø	MN	75.0– 86.0	69.0– 81.0	–
8 Lidsø	MN	74.0– 99.0	68.0 89.0	–
9 Ørum AA	MN	–	81.0	–
13 New Grange	LN	67.5– 103.4	61.0– 93.1	67.6– 78.2
16 Sorte Muld, Dalshøj	IA	–	62.0– 82.0	–
19 Eketorp II	400– 700	–	62.7– 77.8	–
20 Eketorp III	1000– 1300	–	57.7– 83.4	–
21 Lund	1020– 1400	67.0– 77.0	60.0– 73.5	–
22 Slågarp (aurochs ♀)	EB	93.0	86.5	

Table 40. **Cattle.** Measurements of the **Radius;** max. breadth of the proximal end (BP), max. breadth of the facies articularis proximalis (BFp) and max. breadth of the distal end (Bd). Measurements of the **Tibia;** max. breadth of the proximal end (Bp) and max. breadth of the distal end (Bd). Estimated values underlined. Juvenile (j). Data in mm.

		Radius			Tibia	
Locality	**Age**	**BP**	**BFp**	**Bd**	**BP**	**Bd**
1 Alvastra Eastern Trench	MN	73.6 76.3, 76.7, 78.7	69.1, 69.8, 71.6, 72.1	65.9, 66.0, 67.4, 67.6	<u>94.0</u>	<u>55.8</u>, 58.3, 59.0, 63.2
2 Alvastra L. Hedell	MN	78.0	–	64.0, 71.0	–	57.0, 58.5, 64.0, 68.0, 73.0,
3 Alvastra J. Ekman	MN	77.5	73.5	–	–	57.0 66.2 69.4
4 Cave *Stora Förvar*	N (mainly)	67.0– 75.0	–	63.0– 76.0	79.0j 89.0, 105.0	55.0– 59.0
5a Troldebjerg	MN	–	–	65.5– 88.0	–	–
7 Bundsø	MN	71.0– 93.0	–	63.0– 78.0	–	57.0 70.0
8 Lidsø	MN	77.2	–	–	93.2– 113.0	55.5– 70.5
9 Ørum AA	MN	76.0– 87.0	–	–	–	59.0– 62.0
10 Aalborg	MN	78.0	–	–	–	65.0
13 New Grange	LN	68.3– 97.2	63.0– 88.4	74.2– 89.1	–	58.4 71.0
14 Hötofta	BA	68.0– 76.0	–	–	–	52.0– 61.0
16 Sorte Muld, **17 Dalshøj, Vejleby**	IA	69.5– 87.0	–	–		50.0– 61.0
19 Eketorp II	400– 700	63.4– 84.3	60.2– 77.5	52.3– 75.0	–	50.5– 61.9
20 Eketorp III	1000– 1300	63.5– 89.1	58.1– 82.3	51.8– 81.0	–	49.4– 66.3
22 Slågarp (aurochs ♀)	EB	95.0	87.5	89.0	122.0	78.5

Table 41. **Cattle.** Measurements of the **Talus;** max. lateral length (GL1), max. medial length (GLm), max. lateral depth (D1), max. medial depth (Dm) and max. breadth of the distal end (Bd). Estimated value underlined. Data in mm.

Locality	Age	GL1	GLm	D1	Dm	Bd
1 Alvastra	MN	61.8,	–	30.3,	–	–
Eastern Trench		64.4,	59.6,	36.6,	37.5,	–
		67.0	60.9	42.0	42.3	50.9
2 Alvastra	MN	67.4	–	–	–	–
L. Hedell		–	59.6,	–	–	41.3,
		–	73.0	–	–	49.5
3 Alvastra	MN	63.8,	–	–	38.0,	–
J. Ekman		63.0,	–	–	38.4,	–
		66.5,	–	–	39.9,	–
		76.5	–	–	47.0	–
4 Cave	N	53.0–	–	–	–	32.0–
Stora Förvar	(mainly)	65.0				42.0
7 Bundsø	MN	60.0–	–	–	–	–
		74.0				
8 Lidsø	MN	62.5–	58.3–	–	–	36.0–
		75.0	68.9			48.5
9– Ørum AA, Aalborg	MN	62.5–	–	–	–	–
11 Leire AA		74.0				
13 New Grange	LN	56.2–	–	–	–	36.5–
		71.6				49.0
14 Hötofta	BA	57.0–	–	–	–	–
		64.0				
17 Vejleby	IA	53.0–	–	–	–	–
		61.0				
19 Eketorp II	400–	53.6–	49.2–	–	–	32.1–
	700	67.9	60.8			45.3
20 Eketorp III	1000–	53.9	49.9	–	–	32.7–
	1300	69.4	63.9			46.4
21 Lund	1020–	56.5–	50.0–	–	–	35.0–
	1400	67.5	59.0			45.5
22 Slågarp	EB	82.0	–	–	–	50.0
(aurochs ♀)						

Table 42. **Cattle.** Measurements of the **Calcaneum;** max. length (GL) and max. breadth (GB). Without tuber calcanei (wtc). Measurement of the **Centrotarsal;** max. breadth (GB). Data in mm.

		Calcaneum		Centrotarsal
Locality	**Age**	**GL**	**GB**	**GB**
1 Alvastra	MN	126.5,	–	48.4,
Eastern Trench		132.9,	31.5,	49.6,
		134.7	31.9	51.0,
				52.3,
				54.1
2 Alvastra	MN	132.0	33.3,	48.0,
L. Hedell		–	27.7 wtc	48.5,
		–	30.3 wtc	51.8,
		–	34.5 wtc	52.0
		–	38.5 wtc	
3 Alvastra	MN	131.1	–	47.8,
J. Ekman				51.4,
				55.7
4 Cave	N	111.0–	31.0–	–
Stora Förvar	(mainly)	145.0	41.0	
7 Bundsø	MN	112.0–	–	–
		160.0		
9 Ørum AA	MN	132.0	–	–
13 New Grange	LN	132.4–	–	43.8–
		152.5		65.9
19 Eketorp II	400–	105.1–	–	42.2–
	700	135.1		57.6
20 Eketorp III	1000–	108.3	–	43.7–
	1300	133.6		57.6
21 Lund	1020–	108.0–	–	–
	1400	130.0		
22 Slågarp	EB	162.0	51.0	65.0
(aurochs ♀)				

Table 43. **Cattle** measurements of **Metacarpals** and **Metatarsals;** max. breadth of the proximal end (Bp), max. breadth of the distal end (Bd) and max. length (GL). Juvenile (j). Data in mm.

		Metacarpals			Metatarsals		
Locality	**Age**	**Bp**	**Bd**	**GL**	**Bp**	**Bd**	**GL**
1 Alvastra	MN	–	64.9	–	–	54.6	–
Eastern Trench		–	67.1	–	–	–	–
2 Alvastra	MN	54.5,	56.0,	–	40.0,	49.0,	–
L. Hedell		64.0,	66.0,	199.0,	50.5,	51.0,	–
		55.5	–	–	–	65.0,	250.0
		67.0	67.0	219.0	51.0	67.0	–
3 Alvastra	MN	53.2,	54.2,	–	50.0	47.8,	–
J. Ekman		53.9,	–	–	52.1	63.0,	248.0
		54.0,	–	–	–	50.5	–
		54.5,	–	–			
		61.0,	64.3	196.5,			
		65.0	65.7	217.0			
4 Cave	N	50.0–	50.0,	168.0	37.0–	43.0,	171.0j
Stora Förvar	(mainly)	57.0	56.0,		51.0	47.0,	
			65.0			52.0,	
						56.0	
5b Troldebjerg	MN	–	53.0–	192.0–	–	–	–
			73.0	214.0			
7 Bundsø	MN	53.3–	56.8–	196.0–	43.0–	51.0–	224.0–
		66.8	71.0	204.0	52.0	64.0	237.0
8 Lidsø	MN	56.9,	55.8–	197.5,	–	51.7–	–
		63.4	66.5	201.3		58.0	
9– Ørum AA, Aalborg	MN	59.0–	55.0–	–	–	51.0–	–
11 Leire AA		73.0	71.0			72.0	
12 Aamosen	MES-MN	52.5	48.5	177.0	–	53.0,	
						56.0	
13 New Grange	LN	49.9–	54.0–	190.0–	39.4–	52.3–	233.0,
		70.8	74.0	212.0	57.8	68.2	241.0
14 Hötofta	BA	–	–	–	47.0	51.0	–
15 Voldtofte,	BA	48.0–	50.0	–	165.0–	–	–
Hilleröd		59.0	66.0	205.0			
16 Sorte Muld,	IA	45.0–	47.0–	171.0–	40.0–	46.0–	200.0,
17 Dalshøj, Vejleby,		61.0	63.0	203.0	51.0	62.0	203.0
18 Borrebjerg							
19 Eketorp II	400–700	44.9–	47.9–	170.7–	37.5–	43.5–	198.0–
		61.2	58.6	196.9	50.1	59.5	216.2
20 Eketorp III	1000–1300	45.0–	47.6–	166.0–	35.0–	42.6–	188.9–
		60.5	65.1	199.0	52.9	58.7	228.3
22 Slågarp	EB	67.5	68.5	238.0	58.0	65.5	273.0
(aurochs ♀)							

Table 44. **Cattle.** Measurements of **Phalanx I,** anterior (a), posterior (p) and anterior/posterior (a/p); max. length of the peripheral half (Glpe), max. proximal breadth (Bp), max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Data in mm.

		Glpe		Bp		Bd		SD
Locality	**Age**	**a**	**p**	**a**	**p**	**a/p**	**p**	
1 Alvastra	MN	52.5,	51.1,	–	27.8,	22.3,	25.3	22.4p
Eastern Trench		54.7	65.2	31.6,	29.5	28.3,	–	–
		–	–	33.7	–	33.0	–	–
2 Alvastra	MN	69.0,	67.0,	–	30.5,	32.0	–	27.0a
L. Hedell		70.0	67.0,	–	30.5	–	–	29.0a
		–	72.0	–	–	–	–	30.5p
		a/p		a/p				30.5p
		57.0,	73.0,	31.0	–	–	–	29.0p
		63.7,	73.0,					
		65.0,	73.0					
		70.0						
		a/p						
3 Alvastra	MN	54.0,	65.2,	–	–	–	–	–
J. Ekman		55.5,	66.0,					
		61.0,	67.0,					
		64.0,	67.5,					
		64.5,	68.0,					
		64.7,	69.0					
		65.1,						
7 Bundsø	MN	55.0	–	26.6–	26.5–	26.0–	24.2–	22.0–a
		70.5		37.0	35.0	37.0	34.0	31.7
9 Ørum AA	MN	66.5	69.0	–	–	–	–	–
		a/p						
10 Aalborg	MN	59.0,		–	–	–	–	–
		75.2						
		a/p		a/p		a/p		
13 New Grange	LN	57.2–		25.3–		22.5–		–
		70.1		36.8		33.2		
		a/p		a/p		a/p		
14 Hötofta	BA	59.5		35.0		33.0		28.5a/p
		a/p						
17 Vejleby	IA	54.5,	61.0	–	–	–	–	–
		57.0						
19 Eketorp II	400–	47.6–	48.5–	23.7–	20.9–	–	–	–
	700	56.4	61.4	34.3	32.0			
20 Eketorp III	1000–	45.1–	48.1–	21.6–	21.9–	–	–	–
	1300	60.9	61.7	39.3	32.3			
		a/p						
21 Lund	1020–	50.5–		–	–	–	–	–
	1400	64.5						
22 Slågarp	EB	67.0	70.0	36.0	33.5	32.5	31.5	31.0a
(aurochs ♀)								30.0p

Table 45. **Cattle.** Measurements of **Phalanx II,** anterior (a), posterior (p) and anterior/posterior (a/p); max. length (GL), max. proximal breadth (Bp) and max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Mean value ($\bar{x}$). Numbers = n. Data in mm.

Locality	Age	GL		Bp		Bd		SD
		a	p	a	p	a	p	
		a/p		a/p		a/p		a/p
1 Alvastra Eastern Trench	MN	34.6, 36.1, 36.8, 37.1, 37.7	37.7, 37.8, 39.1, 39.7	26.1, 26.9, 27.8, 30.7, 27.3	26.2, 30.0, 33.4, 31.1	20.6, 22.3, 22.7, 26.7, 22.8	20.1, 25.4, 27.4, 26.4	19.5, 21.8, 22.2, 23.5, 22.1, 19.4, 23.3, 25.0, 24.9
2 Alvastra L. Hedell	MN	45.0, 45.0, 40.0	39.0, 40.0, 40.0, 40.0	– – – –	27.0, 31.5, 31.5, 31.9	–	–	27.5a 27.5a 21.0p 26.5p 25.1p
		a/p						
		38.5, 39.0, 42.0,	44.0, 45.0, 46.0	–	–	–	–	26.1p
		a/p						
3 Alvastra J. Ekman	MN	35.2, 35.7, 36.0, 36.5, 36.8, 37.0, 38.3,	39.5, 40.0, 41.0, 42.0, 42.0, 42.0, 42.5	–	–	–	–	–
		a/p		a/p		a/p		
13 New Grange	LN	38.5–47.6		23.0–36.4		19.0–31.6		–
19 Eketorp II	400–700	28.7–38.5	31.4–39.7	22.0–33.5	21.0–30.3	17.9–27.9	17.6–24.9	–
20 Eketorp III	1000–1300	29.3–39.7	30.7–40.5	22.6–33.9	21.1–31.5	18.5–29.7	17.5–25.7	–
22 Slågarp (aurochs ♀)	EB	41.0	45.0	34.0	33.0	–	–	28.0a 27.0p
		a/p						
1–3 Alvastra n = 36	MN	$\bar{x}$ 39.6 ± 3.0						

Table 46. **Cattle.** Measurements of **Phalanx III,** anterior (a), posterior (p) and anterior/posterior (a/p); max. diagnoal length of the sole (DLS), length of the dorsal surface (Ld) and breadth in the middle of the sole (MBS). Estimated value underlined. Data in mm.

		DLS		Ld		MBS	
Locality	**Age**	**a**	**p**	**a**	**p**	**a**	**p**
		a/p		a/p		a/p	
1 Alvastra	MN	45.8,	67.0,	37.7,	46.1,	14.3,	19.5,
Eastern Trench		48.5,	78.2	34.0,	56.6	15.3,	27.2
		59.1,		46.0,		20.8,	
2 Alvastra	MN	75.0	83.0	–	–	25.0,	28.0
L. Hedell		77.0				24.0	
		a/p					
		67.0,		–	–	–	–
		75.0,					
		86.0					
		a/p					
3 Alvastra	MN	61.7,	75.4,	–	–	–	–
J. Ekman		68.5,	82.2,				
		71.8,	85.0,				
		74.6,	88.5				
		74.8,					
		a/p					
13 New Grange	LN	60.8–		–	–	–	–
		87.2					
22 Slågarp	EB	84.0	76.0	63.0	62.0	–	–
(aurochs ♀)							

Table 47. **Withers height** for **cattle.** The estimations are based on measurements of metacarpals (GL) given in Table 43. The formulae for determination of height are: ♀♀ 6.95 (x) − 20.1 ± 4.5 and ♂♂ 10.49 (x) − 91.5 ± 5.5, where x is the bone length in cm (Sjøvold 1986). The factors given by Matolsci (1970/71, p 113) for corresponding estimations are 6.03 (♀♀) and 6.33 (♂♂). The measurements, estimates and standard deviations are given in cm. Sjøvold (T.S.), Matolsci (J.M.).

Locality	Age	Metacarpal T.S. (♀)	Metacarpal J.M. (♀)	Metacarpal T.S. (♂)	Metacarpal J.M. (♂)
2 Alvastra L. Hedell	MN	118.2, 132.1	120.0, 132.1	117.3, 138.2	126.0, 138.6
3 Alvastra J. Ekman	MN	116.5, 130.7	118.5, 130.9	114.6, 136.1	124.4, 137.3
4 Cave *Stora Förvar*	N (mainly)	96.7	101.3	84.7	106.3
5b Troldebjerg	MN	113.3–* 121.0	115.8–* 122.4	126.2–** 133.0	131.3–** 135.5
7 Bundsø	MN	116.1– 121.7	118.2– 123.0	114.1– 122.5	124.1– 129.1
8 Lidsø	MN	117.2– 119.8	119.1– 121.3	115.7– 119.7	125.0– 127.4
12 Aamosen	MES- MN	102.9	106.7	94.2	112.0
13 New Grange	LN	127.2 – –	127.8 – –	130.9, 107.8,** 116.2,**	134.2, 120.3,** 125.3,**
15 Voldtofte, **Hillerød**	BA	94.6– 122.4	99.5– 123.6	81.6– 123.6	104.4– 129.8
16 Sorte Muld, **17 Dalshøj, Vejleby** **18 Borrebjerg**	IA	98.7– 121.0	103.1– 122.4	87.9– 121.5	108.2– 128.5
19 Eketorp II	400– 700	98.5–* 116.8	102.9–* 118.7	89.9–** 95.2	109.4–** 112.7
20 Eketorp III	1000– 1300	102.4–* 118.2	106.3–* 120.0	82.6–** 108.1	101.3–** 120.5
22 Slågarp (aurochs ♀)	EB	145.3	143.5		

* In the original works the metacarpals are identified as coming from females.
** In the original works the metacarpals are identified as coming from males.

Table 48. **Withers height** for **cattle.** The estimations are based on measurements of metatarsals (GL) given in Table 43. The formulae for determination are: ♀♀ 6.86 (x) – 40.3 ± 4.8 and ♂♂ 7.97 (x) – 58.9 ± 5.3, where x is the bone length in cm (Sjøvold 1986). The factors given by Matolsci (1970/71, p 113) for corresponding estimations are 5.33 (♀) and 5.62 (♂). The measurements, estimates and standard deviations are given in cm. Sjøvold (T.S.), Matolsci (J.M.). Juvenile (j).

Locality	Age	Metatarsal T.S. (♀)	Metatarsal J.M. (♀)	Metatarsal T.S. (♂)	Metatarsal J.M. (♂)
2 Alvastra L.Hedell	MN	131.2	133.3	140.4	140.5
3 Alvastra J. Ekman	MN	129.8	132.2	138.8	139.4
4 Cave *Stora Förvar*	N (mainly)	77.0j	91.1j	77.4j	96.1j
7 Bundsø	MN	113.4–122.3	119.4–126.3	119.6–130.0	125.9–133.2
13 New Grange	LN	119.5, 125.0	124.2, 128.5	126.8, 133.2	131.0, 135.4
16 Sorte Muld,	IA	96.9–	106.6–	100.5–	112.4–
17 Dalshøj, Vejleby, **18 Borrebjerg**		99.0	108.2	102.9	114.1
19 Eketorp II	400–700	95.5–* 106.2	105.5–* 113.8	107.1–** 113.4	113.4** 121.5
20 Eketorp III	1000–1300	89.3–* 111.9	100.7–* 118.3	91.9–** 123.1	106.3–** 128.3
22 Slågarp (aurochs ♀)	EB	147.0	145.5	–	–

* In the original work the metatarsals are identified as coming from females.
** In the original work the metatarsals are identified as coming from males.

7.1.2 Sheep (Ovis ammon f. aries)

Sheep are like cattle both grazers and browsers. Both species are, however, to a great extent grazers (Lepiksaar 1963, p 34, Ahlén 1965, p 366). The locality of the Alvastra pile dwelling may well have offered favourable conditions in which to keep sheep. There was probably access to good pasture and fodder in the groves of coppice woods and other areas rich in grass, plants and herbs.

It has in many studies been emphasized that the domestication of sheep did not take place in Northern Europe, since there was never any wild species of sheep. The mouflon *(Ovis musimon),* nowadays introduced to many European countries, is the only wild sheep living in Europe, and thus has been considered by some authors as one possible progenitor of the domestic sheep found in prehistoric bone assemblages in Northern Europe (for example Pira 1909, p 179, Lieberkind 1937a, p 239–243, Degerbøl 1939, p 161, Lepiksaar 1973, p 224, 1977b, p 84). The mouflon has a rather high proportion of hornless females which is not the case

for other species of wild sheep. On the other hand hornless ewes are common in domestic breeds of sheep (Clutton-Brock 1981, p 54). The mouflon has a withers height of between 65 and 75 cm and a weight of between 25 and 50 kg (van den Brink 1958, p 174–175). However, it has also been suggested that the Asiatic mouflon *(Ovis orientalis)* is probably the progenitor of all domestic sheep and possibly also of the European mouflon. This means that the European mouflon, instead of being a relic of a wild species, is more likely to be a bewildered relic of a domestic sheep brought to Europe for the first time by Neolithic farmers about the seventh millenium B.C. (Clutton-Brock 1981, p 53).

Behavioural studies have shown that the sheep have a social system that is based on a single dominant leader. This makes it easy to shepherd them together and to protect them. It should be pointed out that they thrive better when they are crowded together, both males and females. Also, they are not considered to be nervous animals and can if neccessary easily be constrained by fences (Clutton-Brock 1981, p 55–56). Thus, flocks of sheep were probably relatively easy to handle by early farmers, especially if they wanted some areas to be protected from being too heavily grazed. Also, like cattle, sheep probably had to be protected from predators existing in the neighbourhood.

Among the sheep remains in the bone material from the Eastern Trench some specimens, from probably adult individuals, show variation in size and morphology (Section 4.1.2). The few measurements which could be taken agree with data available from the analysed bone material derived from the earlier excavations of the pile dwelling, as well as with other sheep dimensions such as from the *Stora Förvar* cave on the isle of *Stora Karlsö* near Gotland in the Baltic (Table 49). In this connection it should, however, be noted that there is a possibility that the material from *Stora Förvar* is not accurately dated. Albeit, it has been pointed out elsewhere (Pira 1926/27, p 172–176) that the remains of the presumed Neolithic sheep from *Stora Förvar* showed a great dispersion in size among the adult individuals, and that this variation cannot be explained by sexual dimorphism alone, but was probably due to primitive stockbreeding, haphazard mating, inbreeding and insufficient selection. In addition it is noted by Pira that, in a study of the length of metacarpals and metatarsals from sheep unearthed in Stockholm (Kinberg 1869, p 368–372, 386–391), it appears that the sheep of the Middle Ages show just as great a dispersion in size as was the case with the sheep from the *Stora Förvar* cave. The measurements in Tables 49 and 50 provide an example of size variation in sheep specimens during Prehistory and the Middle Ages in Sweden. It may be noted that it has more recently been stated (Spahn 1978, p 52) that the limb bones from sheep do not show any sexual dimorphism.

Studies on Danish Neolithic sheep have shown that the limb bones in particular seem in general to indicate small and slenderly built animals (Winge 1908, p 184, Degerbøl 1939, p 165–166). Limb lengths in the Bundsø sheep suggest a withers height of about 60 cm. Similar withers height (a range of 52–62 cm) has been suggested for the sheep stock from the Beaker Settlement at New Grange (van Wijngarden-Bakker 1980, p 168–169). For comparison an attempt has been made to estimate the withers heights of the sheep from the *Stora Förvar* cave by means of the lengths of 26 metacarpals (Mc) (116–143 mm) and 30 metatarsals (Mt)

(115–148 mm) from the remains of the specimens. The formulae used have been provided by Sjøvold (1986):
Withers height = 3.33 (Mc) + 21.4 ± 1.6 and
withers height = 3.14 (Mt) + 20.8 ± 1.5.
All measurements, estimates and standard deviations are given here in cm. The formulae calculated by Teichert (1975) are also used. The application of Sjøvold's formulae resulted in withers heights of about 60–69 cm (Mc) and about 57–67 cm (Mt). Using Teichert's formulae, withers heights of about 57–70 cm (Mc) and 52–67 cm (Mt) were obtained. The results indicate that the Swedish Neolithic sheep may at times have attained withers heights within a range of mouflon (65–70 cm).

Compared to cattle the relative frequency of sheep is fairly low in the bone material from the Eastern Trench, indicating that sheep did not play such an important part in the economy as cattle. This assumption is supported by the results from the unpublished analyses by Hedell and Ekman of bone material from parts of the pile dwelling in which the sheep fragments are comparatively few. In Pira's (1926/27) analysis there is no fragment identified as sheep (Table 31). Moreover, the remains of sheep are relatively uncommon compared to the remains of pig and red deer. Also in many faunal assemblages from Danish settlements dated to the Middle Neolithic period, for instance at Troldebjerg, Blandebjerg, Bundsø and Lidsø, the cattle remains seem to be more frequent than the remains of sheep (Winther 1935, p 46, 1943, p 25, Degerbøl 1939, p 143, Hatting 1978, p 201) indicating that the sheep-keeping was of less importance to the farmers of the Funnel Beaker Culture. It seems, however, that the proportion of sheep had increased among the bone remains by the end of the period (Malmer, 1962, p 801–803).

Thus the sheep bone sample being studied is too small to provide any reliable evidence as to whether the sheep were being kept mainly for meat or for milk. The problem of wool production during Neolithic times in the Nordic countries has already been pointed out (Lepiksaar 1963, p 33). It is in general assumed that the sheep during Neolithic times were kept to provide meat and possibly also milk and that selection for wool production started in the Bronze Age (van Wijngarden-Bakker 1980, p 169). It has been stated that wool has not got a useable quality until after the second winter and meat gets more fatty and less tasty with age (Ekman 1975, p 65). Today meat from animals about 7 months old (at most one year old) with a live weight of 45–50 kg and a carcass weight of 17–20 kg is considered to have the best quality (Slakteriorganisationen 1982). In comparison it should be noted that the sheep in the Early Iron Age are considered to have had an average carcass weight of about 18 kg (Boessneck et al. 1971, p 8–9).

After a pregnancy period of about five months the ewes produce one or two at times three and even four lambs during spring. If one assumes that the Alvastra lamb should have attained a tolerably good carcass weight, giving a satisfactory dressing percentage, before getting killed, late autumn may have been a suitable time of year for slaughter. There is at least one juvenile individual, younger than 16 months, identified in the material. It has not been possible to determine a more accurate time of the killing.

To sum up, the relatively few remains of sheep in bone samples from the pile dwelling indicate that sheep-farming did not play such an important part as cattle-raising in the life and economy of the local human population during the Middle Neolithic. Nevertheless, like the remains of cattle, bones from both young and adult individuals may show that the Alvastra sheep were kept both for meat and dairy produce, and probably also for reproductive purpose as well. Besides providing meat, the fleece could have been used as clothing and the fat as tallow. Bone specimens such as the tibia and metapodials have also been used in manufacturing bone artefacts (Table 76).

Only one atlas (the first cervical vertebra) fragment shows cut marks (Table 77). At least two fragments, a mandible and a tibia but possibly also a scapula fragment, show marks of being gnawed and chewed by animal teeth (Table 78). There is no evidence of pathological, degenerative or traumatic changes on bone elements.

Table 49. **Sheep.** Measurements of the **Talus;** max. lateral length (GL1), max. medial length (GLm), max. lateral depth (D1), max. medial depth (Dm) and max. breadth of the distal end (Bd). Measurement of the **Calcaneum;** max. lateral length (GL). **Sheep** or **Goat** (s/g). Data in mm.

		Talus					Calcaneum
Locality	Age	GLl	GLm	DL	Dm	Bd	GL
1 Alvastra Eastern Trench	MN	27.3	26.8	14.8	15.6	16.7	55.1
2 Alvastra L. Hedell	MN	28.0	–	–	–	–	54.1, 57.7
3 Alvastra J. Ekman	MN	26.6	25.6	–	–	16.8	51.7 s/g, 52.2 s/g, 54.0 s/g
4 Cave *Stora Förvar*	N (mainly)	–	24.0–29.0	–	–	16.0–20.0	50.0–61.0
13 New Grange	LN	26.3, 26.6, 27.6	–	–	–	–	53.2
19 Eketorp II	400–700	23.8–30.9	22.3–29.3	–	–	14.7–20.6	49.0–63.0
20 Eketorp III	1000–1300	23.3–31.1	22.3–30.0	–	–	14.7–20.3	40.3–61.7–
21 Lund	1020–1400	26.0–30.5	21.0–24.5	–	–	17.0–20.5	55.0–60.5
24 Inst. of Zoot, Stockholm (moufflon)	–	–	26.0–30.0	–	–	18.0–20.0	56.0–66.0

Table 50. **Sheep.** Measurements of **Phalanx I;** max. length of the peripheral half (Glpe), max. proximal breadth (Bp), max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Measurements of **Phalanx II;** max. length (GL), max. proximal breadth (Bp), max. distal breadth (Bd), and min. breadth of the diaphysis. Data in mm.

		Phalanx I				Phalanx II			
Locality	**Age**	**Glpe**	**Bp**	**Bd**	**SD**	**GL**	**BP**	**Bd**	**SD**
1 Alvastra Eastern Trench	MN	36.3	11.1	10.2	9.9	21.6	11.1	10.0	9.0
3 Alvastra J. Ekman (sheep/goat)	MN	35.5, 35.7, 36.2	11.0, 11.8, 10.3	10.5, – 9.8	8.1, 9.3, 8.2	–	–	–	–
13 New Grange	LN	28.5–32.1	10.8–11.5	9.6–10.7	–	19.7	10.2	8.5	–
19 Eketorp II	400–700	30.6–40.6	9.7–13.9	–	–	18.4–24.4	9.0–12.3	–	–
20 Eketorp III	1000–1300	29.9–40.7	9.8–14.4	–	–	17.3–26.3	8.0–12.9	–	–

Table 51. **Sheep,** Measurements of **Os carpi 2+3** (C 2+3), **Os tarsi 2+3** (T 2+3) and the **Centrotarsal** (Ct); maximum breadth (GB). Data in mm.

Locality	**Age**	**C 2+3 GB**	**T 2+3 GB**	**Ct GB**
1 Alvastra Eastern Trench	MN	14.3, 14.3, 15.5	14.4	21.9
3 Alvastra J. Ekman (sheep/goat)	MN	–	–	22.4, 22.7

7.1.3 Elk (Alces alces)

The areal distribution of elk corresponds to the circumpolar coniferous forest belt. In contrast to red deer the elk avoids the mixed large deciduous forest of oak, lime and elm and prefers young, mainly deciduous, forests where for instance aspen, willow and birch flourish and also mixed forests with pine. The borders of forests where shrubs, brushes and sprouting vegetation grow are favourite habitats for elk, especially if there are watercourses, fen areas with bogs, tarns and lakes in the neighbourhood. The elk is considered to be a good swimmer. The diet is entirely different during the summer and winter seasons. During the winter time the elk mainly lives on twigs of shrubs and trees and also bark. Species of mosses and lichens are eaten if they live on trees. The elk is mainly a browser. Bilberry and cowberry twigs are eaten both during spring and autumn. During the summer the elk prefers to stay in areas with watercourses. Herbs, especially aquatic ones, and

leaves form the main diet. It seems as if the rootstocks of waterlily are appreciated in particular. In the beginning of the summer the elk feeds also on sedges. Occasionally it may feed on cereal crops and fungi (Lieberkind 1937a, p 150, van den Brink 1958, p 171, Ahlén 1965, p 363, Siivonen 1976, p 130, Ekman & Iregren 1984, p 24). Within the areas where both elk and red deer live it has been concluded that they show different specializations in the biotopes, and it is suggested that they are not in fact ecological competitors (Ahlén 1965, p 365). Considering its social behaviour, the elk is in general solitary and not a gregarious animal, especially not during the summertime. However, during the rutting period, which starts at the end of August, male and female may stay a couple of weeks within the same small area and in the wintertime they can be found in groups. If the covering of snow is deep the elk is sedentary. Elks are predominantly active at dawn and twilight but also during parts of the day and night (Ekman 1910, p 40, van den Brink 1958, p 171, Siivonen 1973, p 130).

It cannot be excluded that there have been biotopes in the Alvastra region during the Middle Neolithic which have suited the elk. The relative frequency of elk is, however, low in the bone material from the Eastern Trench, indicating that the people who used the site did not hunt elk in particular. The results from earlier analyses of bone material from the pile dwelling (Pira 1910, Hedell 1910–1913, 1919, Ekman 1977) show that the remains of elk are also few in this material (Table 31). This may further indicate that the elk was not a common species in the local environment, was not often brought to the site or hunted. On the other hand the elk is essentially solitary, roams over extensive areas and is seldom sedentary, that is, staying within the same area. This means that stalking elk would have required more time and planning than for instance stalking a herd of red deer with its more sedentary way of life, following well-trodden paths (Larsson 1978, p 188–189). Thus elk hunting may have been more sporadic due to the animal's social behaviour and relative inaccessibility to man compared to red deer. Nevertheless it should be noted (von Essen, pers. comm.) that elk has been easier to drive in a certain direction, for instance into a system of hunting pits or towards hidden hunters, than red deer or roe deer. Besides man there were other enemies in the area, the predators brown bear and wolf. If attacked, the elk could defend itself successfully against brown bear and wolf with its hooves (Lieberkind 1937a, p 151–152). Remains of beaver have also been identified in bone materials from the site and their way of life supports the elk. By intensive tree felling and shrub reduction the beaver creates open areas and builds dams. This stimulates the vegetation of sprouts, herbs and aquatic plants and creates a biotope in which the elk thrives (Lavsund 1975, p 35, Lepiksaar 1982, p 121).

The elk is a very large animal with a withers height from 150 up to 220 cm. The weight is given as between 240 and 450/600 kg; sometimes possibly up to 800 kg (van den Brink 1958, p 171, Siivonen 1973, p 129). Its value as a meat producer can be considered as considerable. An attempt has been made to estimate the carcass weight to 175 kg (Larsson 1978, p 187) for Mesolithic remains. This may well be on the small side if one considers the upper limits for the live weight. Even if killing an elk results in quite an amount of meat, the transportation of the whole body intact would be difficult and would demand a considerable effort. Probably

the animal was butchered where it was killed and it is possible that several parts of the heavy skeleton were left behind. It has been pointed out that the meat could have been stripped from the bones and the feet left attached to the hide making convenient handles for carrying or dragging the hide filled with meat. This procedure may create what has been called the 'schlepp effect' showing a disparity in the number of bones (Perkins & Daly 1968, p 104).

The female elk produces from one to three calves in May–June time. In the Eastern Trench material there are remains of one calf probably less than 2 years old. During which period of the year this animal was killed cannot be determined by means of the skeletal remains.

Prehistoric groups were not simply killing the elk for meat. Hides, skins and sinews could have been used in various ways. Some bones, such as the metapodials, have provided raw material for the manufacture of bone artefacts, showing that elk bone has been attractive for this kind of work (Table 76).

None of the fragments show distinct butchery marks. The degree of fragmentation of the remains may, however, indicate that the bones have been subjected to, for instance, marrow extraction. Two fragments, one juvenile fused epiphysis from a radius and ulna and one femur diaphysis, show marks of being gnawed and scored by animal teeth, probably dog teeth (Table 78).

One lateral metacarpal (metacarpal II or V), a so-called stilleto-bone, shows signs of an incompletely healed injury, possibly due to a fracture of the proximal, thin part of the diaphysis. There is definite evidence of repair, with some callus formation. It seems as if a 'false joint', a pseudo-arthrosis, could have been developed but the rest of the bone, its thinnest part, is missing (Fig.20). There may also have been an inflammatory reaction. A description of ante-mortem bone damage has been given by Baker & Brothwell (1981, p 82–95), who point out that, when healing has taken place, it is difficult to establish what caused the injury, for example whether it was the result of a hunter's arrow or a natural fall by the animal.

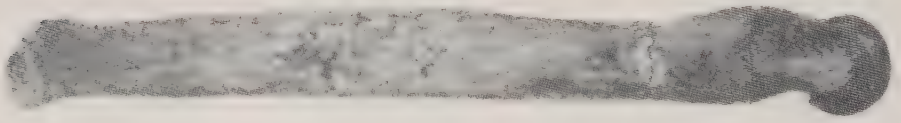

Fig. 20. ELK. STILLETO-BONE (metacarpal II or V) showing an incompletely healed injury. Scale 1:1.

7.1.4 Red deer (Cervus elaphus)

The red deer is primarily a species which prefers large mixed deciduous forests. It has a distinct day and night rythm. During the daytime it is rather inactive, spending the time in dense forests and thickets. When dusk falls it seeks out more open forest and grounds to be pastures during the night. The red deer feeds on buds, leaves, herbs, berries, fungi, heather, lichen and the twigs and bark of such trees and shrubs as spruce, oak, ash and willow. It also has a predilection for grazing plants like clover and leguminous plants and also eats ripe cereals. The choice of food depends on the season of the year. Furthermore, the red deer prefers biotopes where there are source-streams and waterlogged grounds with shallow water. In these areas so-called 'soil pits' are to be found. The red deer likes to get into these 'soil pits' when it returns at dawn from feeding. It is considered to be a good swimmer and, moreover, it climbs well up steep slopes. Compared to elk it cannot advance as easily in fen areas and boggy ground. Comparative studies have shown that the elk has no distinct part to play in the ecology of the red deer and they are not in general competitors in terms of feeding (Section 7.1.3). As to social behaviour the red deer is a relatively sedentary and gregarious animal, a herd animal. Usually the herd remains within a limited area. Stags and hinds live in separate herds most of the year except for the rutting period in the fall (Lieberkind 1937a, p 170–171, van den Brink 1958, p 169–170, Ahlén 1965; III, Siivonen 1976, p 128, Clutton-Brock et al. 1982; Chapter 9).

The existence of a biotope of mixed forest, coppice woods, open ground and waterlogged regions in the environment surrounding the pile dwelling has provided excellent ecological conditions for the red deer in the Middle Neolithic. Considering the results from the Eastern Trench the red deer, as well as pig, seem to have been valuable meat producers. Red deer has the highest frequency among the cervids. The results from the earlier unpublished analyses by Hedell and Ekman support this assumption. In Hedell's analyses from 1910–1913, as in the material from the Eastern Trench, cattle are the most common, followed by wild boar or domestic pig and red deer. In Hedell's analysis of 1919 red deer is more common than cattle but not as common as wild boar and possibly domestic pig. In Ekman's analysis (1977) red deer is the most common species. Only in Pira's analysis (1910) are the remains few (Table 31).

The red deer has qualities which make it easier to stalk than other deer. Its lack of movement provides plenty of opportunities for human groups to keep herds under observation. This may contribute to a successful, selective hunting and killing. The red deer has since Mesolithic/Atlantic times been one of the most important meat producers for prehistoric groups in Southern Sweden (Larsson 1978, p 188, 209, 1983, p 110, Lepiksaar 1982, p 110). In the environment around the Alvastra pile dwelling the population of red deer was not only hunted and killed by man, but there were also other predators in the neighbourhood such as brown bear, wolf and lynx.

The red deer is a fairly large herbivore with a withers height between 120 and 150 cm. The live weight is about 60 to 240 kg, some males can weigh more than

300 kg (van den Brink 1958, p 169, Siivonen 1976, p 128). An attempt to estimate the carcass weight for Mesolithic red deer in Scania, southern Sweden, results in a figure of 150 kg (Larsson 1978, p 187).

According to various studies, prehistoric red deer seem to have been larger than today's animals (Ahlén 1965, p 169, 173, Noddle 1982, p 318, Clutton-Brock et al. 1982, p 11). It has further been demonstrated that, on the basis of measurements of the maximum length of talus (Glm), the Danish red deer but not the Norvegian red deer show a decrease in size from Boreal to Subboreal times (Ahlén 1965, p 151, 174). In comparison, available measurements of the talus in bone material from the pile dwelling and from Swedish Boreal and Atlantic finds have been considered. The maximum lateral lengths (GLl) show that there are tali of larger size in the Mesolithic material but the mean value of the maximum medial length (Glm) is larger (51.0 mm) calculated on tali from the pile dwelling than that of the same mean value (45.2 mm) given by Ahlén (1965, p 150) on 95 tali from the Mesolithic (Table 53). However, besides being biased in terms of sex and age, the Alvastra sample is also far too small for any conclusions to be drawn as regards a change of size in Swedish material between these time periods. One can at least say that the results indicate no decrease. In general the available measurements are too few to allow any reliable comparison of the size of the Alvastra red deer with other Neolithic or younger populations (Tables 52, 54, 56 and 57).

For the red deer the rutting period begins during late summer/early autumn and may last into September. The stags establish territories which they defend. Violent fights may occur. The calf is born in May – June time and it is carefully protected by the hind during its first weeks of life (Siivonen 1976, p 128, Clutton-Brock et al. 1982, p 78, 139). At what time of year the four individuals identified in the Eastern Trench material were killed cannot be accurately determined since their individual age could not be placed within sufficiently narrow age ranges (Table 13).

Considering the representation of separate bone specimens, some elements, such as foot bones, seem to be better represented than others, for instance vertebrae and ribs. This may depend on various taphonomic factors, such as the inherent potential for preservation of the bone element or a butchering technique creating the so-called 'schlepp effect'. It may also result from a deliberate selection of anatomical parts before the red deer were brought to the site. It must be stressed that the analysed material is a small sample and that the presence (or absence) of bone elements may be of a stochastic nature. High or low frequencies of identified species may depend on a more heterogeneous distribution of different species over the total area. The relative frequency of red deer seems in general to be fairly small in the studied bone materials from the pile dwelling when compared to the relative frequency of cattle. This has also been pointed out by Hedell (unpublished notes) and supports the view that animal husbandry played a vital part in the human life and economy of the Alvastra people. Some results show, however, (Table 31) that at times remains of red deer have been more frequent than those of cattle. This indicates that differences can exist between different parts of the pile dwelling. There is the possibility that the game was intentionally divided among people and

thus become associated with different parts of the site. This may have resulted in heterogeneity not only in the relative frequency of species but also in terms of the distribution of body regions and individual bone elements (Gilbert & Singer 1982, p 25–27), which in turn affect the representation of a species within a bone sample. For different reasons, such as food demands or customs, the need and desire to get venison or use the carcass could have varied from time to time. There is also the possibility that the occurrence of herds of red deer fluctuated at times in the resource area making access to game not always the same. Hence, irrespective of whether the red deer remains come from a small sample, there are various factors which may have affected the bone material and influenced the quantitative interpretation of red deer remains.

These reasons for the variation and differences in the relative frequencies of the red deer remains may, of course, be valid in general for other species identified in the bone material.

Red deer had probably not been hunted and killed just for meat and as in other species the hides would certainly been used in various ways. Antlers and other bone specimens, such as ulnae and metapodials, were used in manufacturing various tools (Table 76). With respect to the finds of antler in the Eastern Trench material it has not been possible to decide whether the fragments come from shed antlers or not. The antlers are shed from the end of February to May (Lepiksaar 1983, p 129). Without knowing where to find the animals during this particular time, it is hard to find antlers preserved, since they may be destroyed by rodents within a couple of weeks (Larsson 1978, p 188). At the present day also the deer will gnaw and chew at them, possibly to replace valuable minerals (Clutton-Brock 1981, p 164). It has been estimated that today an antler crown may weigh between 5 and 8 kg, sometimes up to 12 kg or more (Lieberkind 1937a, p 168). Antler has thus formed an attractive råw material for the manufacture of artefacts. Furthermore, experimental studies have shown that antler from red deer is far superior to elk antler in making projectile points (Guthrie 1983), as the elk antler is claimed to be thinner.

In sum it can be established that red deer hunting probably played a definite role in the life and economy of the people who used the pile dwelling. Possibly Middle Neolithic communities also needed to protect crops and harvests against the damage these herbivores could cause. The people may of course have taken advantage of this arranging traps etc. for the capture of such game. When interpreting prehistoric hunting tactics this must deeply be considered. With respect to hunting it has been argued (Gejvall 1969, p 46) that the large antler of male deer constitute a 'natural handicap' in man's favour during hunting both with spear and snare. This could have encouraged the capture and killing of males rather than that of the shyer and hornless female, especially during the rutting period.

One rib, two metapodials and one phalanx show marks from the butchery process and of marrow extraction (Table 77). At least 15 fragments show marks of being gnawed and chewed by dogs and possibly also by other carnivores and omnivores (Table 78). No evidence of inflammatory, degenerative or traumatic changes were noted on the remains of red deer.

Table 52. **Red deer.** Measurements of the **Ulna;** depth across the processus anconeus (DPA) and max. breadth across the coronoid process (BPC). Measurement of the **Tibia;** max. breadth of the distal end (Bd). Juvenile (j). Data in mm.

		Ulna		Tibia
Localtiy	**Age**	**DPA**	**BPC**	**Bd**
1 Alvastra Eastern Trench	MN	43.4, 57.1	– 31.6	48.5j, 48.5
3 Alvastra J. Ekman	MN	–	26.0, 30.8	42.6, 49.0, 53.5, 61.0
12 Aamosen	MES- MN	–	–	38.5– 54.0
24 Sweden (Atlantic time)	MES	–	–	42.3– 51.1
26 Sweden (Boreal time)	MES	–	–	40.0– 55.0
27 Great Britain	N	–	–	41.0– 45.0
Great Britain	BA	–	–	47.0, 48.0
Great Britain	IA	–	–	43.0– 54.0
Great Britain	MA	–	–	30.0– 54.0
28 Sweden (modern red deer)		–	–	45.0– 52.0
29 Great Britain (modern red deer)		–	–	35.0– 52.0

Table 53. **Red deer.** Measurements of the **Talus;** max. lateral length (GL1), max. medial length (Glm), max. lateral depth (D1), max. medial depth (Dm) and max. breadth of the distal end (Bd). Data in m. Mean values ($\bar{x}$).

Locality	Age	GL1	GLm	D1	Dm	Bd
1 Alvastra Eastern Trench	MN	53.6	50.0	29.3	30.6	33.8
2 Alvastra L. Hedell	MN	54.0	–	–	–	–
3 Alvastra J. Ekman	MN	52.3, 52.6, 53.1, 53.2, 53.6, 54.2, 54.3, 54.5 56.0	50.5, 50.3, 50.0, 49.9, 51.2, 51.5, 54.3, 50.8, –	–	–	34.4, 32.3, 32.4, 32.3, 33.6, 33.9, 34.0, 34.5, 34.0
12 Aamosen	MES-MN	41.0–66.0	–	–	–	27.0–37.8
30 Switzerland	N	48.0–62.5	–	–	–	31.0–40.0
13 New Grange	LN	46.6, 51.5	–	–	–	28.5, 30.5
25 Sweden (Atlantic time)	MES	53.0–59.8		–	–	31.6–36.0
26 Sweden (Boreal time)	MES	52.0–64.0		–	–	–
28 Sweden (modern red deer)		50.0–54.2	–	–	–	–
29 Great Britain (modern red deer)		44.0–48.0	–	–	–	–
31 Eastern Europe (modern red deer)		57.0–58.5	–	–	–	36.0–37.0
1–3 Alvastra	MN	$\bar{x}$ 53.8 ± 1.2	$\bar{x}$ 51.0 ± 1.5			$\bar{x}$ 33.5 ± 1.0
32 Sweden	MES		$\bar{x}$ 45.2 ± 4.3			

Table 54. **Red deer.** Measurement of **Metacarpals;** max. breadth of the distal end (Bd). Juvenile (j). Data in m.

Locality	Age	Bd
1 Alvastra Eastern Trench	MN	31.8j, 37.5
3 Alvastra J. Ekman	MN	41.6
7 Bundsø	MN	40.0–47.0
12 Aamosen	MES-MN	42.6, 45.0
33 Star Carr	MES	39.0–49.0
27 Great Britain	N	38.0–42.0
Great Britain	BA	43.0
Great Britain	IA	31.0–44.0
Great Britain	MA	41.0, 45.0
29 Great Britain (modern red deer)		29.0–43.0

Table 55. **Red deer.** Measurement of **Metacarpals** for males (♂) and females (♀). The values are taken from Bosold, 1976, Table 2.

Bd	32.0–37.0	36.0–46.0

Table 56. **Red deer.** Measurement of **Os malleolare** (OS mall.), the fibula; max. depth (GD). Measurement of **OS tarsi 2+3;** max. breadth (GB). Data in mm.

Locality	Age	Os Mall. GD	Os tarsi 2+3 GB
1 Alvastra Eastern trench	MN	26.7	24.9

Table 57. **Red deer.** Measurements of **Phalanx I;** max. length of the peripheral half (Glpe) and max. proximal breadth (Bp). Measurements of **Phalanx II;** max. langth (GL), max proximal breadth (Bp), max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Mean value ($\bar{x}$). Numbers = n. Data in mm.

Locality	Age	Phalanx I		Phalanx II			
		Glpe	Bp	GL	Bp	Bd	SD
1 Alvastra Eastern Trench	MN	55.7	20.2	43.7	20.8	18.5	15.1
2 Alvastra L. Hedell	MN	56.5, 56.5	–	–	–	–	–
3 Alvastra J. Ekman	MN	53.0–63.9	19.0–23.0	39.0–46.1	–	–	13.0–16.8
(Phalanx I:n=20 Phalanx II:n=31)		$\bar{x}$58.6 ±2.9	$\bar{x}$20.8 ±1.1	$\bar{x}$43.2 ±2.0			$\bar{x}$14.5 ± 1.0
34 Windmill Hill	N	44.0–56.0	–	–	–	–	–
35 Skara Brae	N	49.0–62.0	–	–	–	–	–
13 New Grange	N	47.6, 48.0, 51.0	17.5, 17.9, 17.2	34.5–39.0	19.0–25.5	15.7–19.0	–
27 Great Britain	IA	46.0–66.0	–	–	–	–	–
Great Britain	MA	44.0–66.0	–	–	–	–	–
29 Great Britain (modern red deer)		44.0–56.0	–	30.0–42.0	–	–	–

Table 58. **Red deer.** Measurements of **Phalanx I** and **II** for males (♂) and females (♀) . The values are taken from Bosold 1967, Table 2.

Phalanx I			Phalanx II		
	♀	♂		♀	♂
Glpe	43.0–51.5	47.0–58.0	GL	31.0–39.0	34.0–43.0
Bp	16.0–19.0	17.0–24.0	Bp	15.0–18.5	17.0–22.0
			Bd	13.0–16.0	13.0–21.0
			SD	11.0–13.0	12.0–17.0

7.1.5 Roe deer (Capreolus capreolus)

From an ecological point of view the mixed deciduous forest biotope suits the roe deer very well. It thrives especially well in dense young forest growing on chalky soils and with a rich undergrowth where shrubs and twigs flourish. It may also seek more open ground, woodland, meadows, fields and swampy areas with stands of rushes and shore-shubbery. Arable land is also grazed. This animal may thus thrive both in low-lying and upland terrains. The roe deer is mainly a browser and its diet consists to a great extent of buds, leaves and twigs but it can also be seen pasturing the fields. Moreover, it is selective in its preferences and the roe deer may move over large areas to find what it seeks in terms of herbs. It is active both by day and night and, like the elk and red deer, it is a good swimmer. While a selective feeder, the roe deer is in general a rather sedentary animal. It may live alone but usually one buck, a couple of hinds and kids are living together. Especially during the winter roe deers may gather in rather large flocks (Lieberkind 1937a, p 144, van den Brink 1958, p 171, Lundberg 1958, p 649–670, Siivonen 1976, p 132). It has been noted that elk and red deer are not in general to be considered as competitors in feeding (Section 7.1.3). It has also been claimed that all three herbivores, elk, red deer and roe deer, when occupying the same habitat, can coexist there without larger competing for pasture. Besides perhaps some difference in food preference, the differences in size may direct the browsing towards different levels of vegetation in the network of branches of the trees (Lepiksaar 1983, p 142).

The roe deer was well suited to live in the region of the pile dwelling. The area offered both lowland and hillsides to move on as well as areas rich in vegetation to feed on. The relative frequency of roe deer is low in the remains from the Eastern Trench. However, in most of the earlier analyses of bone material from the site roe deer seem to have a better representation (Table 31), indicating that its importance in the economy may have been greater than shown by the remains from the Eastern Trench and that the low frequency may be of stochastic nature. A variety of different reasons may have caused depositional biases as already discussed (Section 7.1.4). The roe deer has been a desirable prey to predators and the kids even to birds of prey in the area. Possibly also its accessibility has thus fluctuated depending to some extent on the degree to which these animals diminished the stock (von Essen, pers. comm.).

The roe deer is a slenderly built small cervid with a withers height between 65 and 75 cm. The live weight is about 15 to 30 kg. The hind is on average smaller than the buck (van den Brink 1958, p 171, Siivonen 1976, p 132). Hence the carcass weight for a roe deer is light and the edible portion in kg relatively low. The carcass weight is estimated to be about 15 kg for Mesolithic animals in Scania (Larsson 1978, p 187).

The female roe deer gives birth to one, two or at times up to four kids between May and June. At what time of the year the probably adult buck, represented in the Eastern Trench material, was killed cannot be accurately determined.

Like other cervids at Alvastra, as well as producing tasty venison roe deer provided hide and skin for clothing and other objects. The carcass also provided

desirable raw material for the manufacture of artefacts in form of metapodials and tibiae (Table 76). There are no finds of roe deer antler in the material. It has been suggested that antler of roe deer is of no practical use (Larsson 1978, p 189). Such a statement, however, may be considered with caution since we can not prove that prehistoric man did not use roe deer antler in some way.

None of the fragments identified as roe deer show distinct butchering or gnawing and scoring marks. There is no evidence of inflammatory, degenerative or traumatic changes on the bones.

Table 59. **Roe deer.** Measurements of the **Mandible:** length of the cheektooth row, along the alveoli on the buccal side (7), height behind M_3 (the alveolus) on the buccal side (15a), height in front of M_1 (the alveolus) on the buccal side (15b) and height in front of P_2 (the alveolus) on the buccal side (15c). Measurements of the **Raidus:** max. proximal breadth (Bp). Data in mm.

		Mandible				Radius
Locality	**Age**	**(7)**	**(15a)**	**(15b)**	**(15c)**	**Bp**
1 Alvastra Eastern Trench	MN	68.0	21.9	18.7	15.1	21.5
2 Alvastra J. Ekman	MN	69.2	24.2	18.5	–	–
12 Aamosen	MES-MN	–	–	–	–	25.8
36 Denmark (modern roe deer)		61.0–66.0				

7.1.6 Wild boar (Sus scrofa)

In Scandinavia wild boar is adapted to areas of large mixed deciduous forests of oak, elm, hazel and other species, as well as open areas with more luxuriant vegetation. In these areas there are plenty of acorns, hazelnuts, insect larvae and worms. Fen areas and arable land are also frequented. The wild boar is primarily a nocturnal animal. During the day the wild boar may seek out warm and sunny places to rest in and digs there its own lair. At dusk it seeks usually out water and is often inclined to grub and roll about in the water and mud before it starts looking for food. It is an omnivore and eats various parts of plants, roots, berries, acorns, hazelnuts and cereals. It digs and grubs for worms and larvae. Small rodents, snails and even pieces of already dead bodies (including pig) may be eaten. The wild boar is a tough animal which at times can move a long way and for a long time. It easily gets over boggy areas and through brushwood. With regard to their behaviour the wild boar has many characters which are similar to those of carnivores. For instance, they are very sociable animals and seem to like bodily contact with their family groups. They build lairs in hollows and have large litters, the piglets at birth being poorly developed physically and can neither stand nor run for the first few

weeks. Furthermore, they feed for many hours and afterwards tend to rest and sleep for many hours. They are however, like other artiodactyls, also gregarious animals so that sows and young animals live together in smaller or larger groups. The wild boar is not a territorial animal. The males are in general solitary except during the rutting time which occurs rater late in the autumn (Lieberkind 1937a, p 78–80, van den Brink 1958, p 168, Siivonen 1976, p 127, Clutton-Brock 1981, p 73–74).

The biotope surrounding the pile dwelling during Middle Neolithic times was an excellent habitat for the wild boar. As well as large deciduous forests and marshland, probably coppice woodland with its twigs and buds and the small arable lands also had their attraction on the wild boar. A group of wild boar can do a lot of harm grubbing in arable land especially when the corn is ripe. If there were refuse dumps in the neighbourhood the wild boar would probably have been scavenging them. Besides being hunted and killed by man there were other predators in the surrounding area constituting a potential threat to the wild boar, especially wolf and also lynx. Likely competitors for food on the ground and in refuse dumps may have been the badger and the red fox.

According to the results from the Eastern Trench wild boar (and probably also domestic pig) seem to have been valuable meat producers, probably the best besides cattle. The results from the earlier analyses support this conclusion. In one of the samples, the one from 1919, the wild boar is the most common species. It has to be noted that the authors do not exclude the possibility that there are remains of domestic pigs in the material (Table 31). Since Mesolithic times the wild boar as well as the red deer was one of the most important producers of meat and sources of protein for prehistoric man. (Larsson 1978, p 189, 209, Lepiksaar 1982, p 113, Lepiksaar 1983, p 142).

In proportion to size the wild boar in general has a high body weight and is thus an important meat producer. Recent wild boar may have a live weight of up to about 150 kg for females and up to about 200 kg for males. The withers height may vary from 85 cm to over 100 cm (van den Brink 1958, p 168, Mohr 1960, p 34, Siivonen 1976, p 126). The carcass weight for Mesolithic wild boars may have been in the region of 75 kg (Larsson 1978, p 187). For comparison the live weights of the large Neolithic pigs from New Grange can be noted. These were calculated to be about 75–100 kg, with an estimated carcass weight of 53–75 kg, allowing for a relatively high dressing percentage of 70 – 75 %. In this carcass weight both skin, head and feet are included. It is argued that of the carcass weight 10 % consists of bones and about 90 % of meat and fat. If at least 5 % of the offal (the parts removed before the carcass weight is estimated) is added, then the total edible portion is about 80 % (van Wijngarden-Bakker 1980, p 159). It has been argued that the human gain was probably more than 80 % of a pig's live weight considering that blood and bone marrow also have food value (Boessneck & al. 1971, p 8). To compare these data on carcass weight with today's, it can be noted that in Sweden today the best meat is considered to come from fattening pigs about 6 to 7 months old with a carcass weight of about 75 kg and live weight of 100–105 kg (Slakteriorganisationen 1982).

The size of the wild boar living in Alvastra during the Middle Neolithic has already been studied by analysing wild boar mandibles from the pile dwelling (Ekman 1974). Ekman (1974, p 216) argues that the size of the Swedish wild boar decreased during post-glacial times, which was in general the case of the European wild boar. He also concludes that the finds of contemporary wild boar specimens from the isle of Gotland, Sweden, do not show any differences in size compared to the ones from Alvastra. Ekman then suggests (1974, p 216 and Fig. 3) that the difference in lengths of the lower third molar of wild boar (between undated finds from bog sites in the province of Scania and Neolithic ones from Gotland) may depend on a chronological difference and not on the domestication of wild boar. The hypothesis that size difference depended on the domestication of wild boar was put forward by Pira as early as 1909. In this connection it may be mentioned that the size of wild boar may also, to a certain extent, depend on environmental influences within the biotope. It has been stated for instance that wild boar living in more humid climates may have a more strongly built body structure than ones living in drier environments (Mohr 1960, p 34). She also states (1960, p 34) that wild boar living on the mainland may be larger than ones living on islands.

As regards the measurement which gave an estimated withers height of 102 cm (Table 66) together with other bone dimensions there seems to be no doubt about the presence of wild boar in the bone material from the Eastern Trench. This conclusion is supported by earlier analyses of pig remains from the site (Pira 1910, p 2, Hedell 1910–1913, 1919, Ekman 1977) and is further confirmed by available measurements from these analyses (Tables 60–64) and by estimating withers heights ($>$ 90 cm) by means of bone specimens from the same material (Table 66).

In the following section an attempt is made to see whether the material from the Eastern Trench and to a certain extent results from the earlier unpublished analyses can provide indications of the presence of domestic pig among the remains of wild boar from the pile dwelling. Considering the measurements of M^3 and bones from the Eastern Trench together with comparable dimensions available from Hedell's and Ekman's materials, they would all seem to indicate variation in size among the pigs suggesting the presence of both larger and smaller animals (Tables 60–64). This may also be seen in the calculated withers heights (Table 66). The individual dimensions seem in general to fall within the ranges previously given for other specimens from Neolithic sites both in Sweden and Denmark (Tables 60–64). The Alvastra material shows, however, some differences. In the case of the length of the third upper molar (M^3) it varies from 40 mm to 48 mm among the large prehistoric Danish wild boar, while the length of M^3 among domestic pigs seldom goes beyond 40 mm (Degerbøl 1939, p 94). In fact the lower limit of the M^3 among wild boar is usually placed at 40 mm (Clason 1967, p 63). Referring to Danish Neolithic material the length of the M^3, from Bundsø and Aalborg in particular, indicate the presence of smaller animals, as well as animals up to the same size as in Alvastra (Table 60). The Danish remains are identified as coming from domestic pigs, *Sus scrofa palustris*, (Winge 1900, p 159, Degerbøl 1939, p 139). The Aamosen bone material may be dated to both the Mesolithic and Middle Neolithic periods. In this case it is suggested that there

is only one single M^3, with a length of 35 mm, that comes from a possibly domesticated pig (Degerbøl 1943, p 201). The length of all the other M^3's exceed 39 mm and are identified therefore as wild boar (Degerbøl 1943, p 186, 196, 198, 200). The scapula measurements from both Bundsø and Aalborg and the tibia dimensions from Bundsø also indicate the presence of smaller animals than suggested by the measurements from Alvastra (Tables 61 and 62). However, considering the measurements of the scapula, it has to be noted that the material is not unambiguous since specimens may be included which are not fully grown. Considering all the bone material from Bundsø it may be noted that Degerbøl does not believe that domestication had taken place at the site and that there are no signs of intermediate forms (Degerbøl 1939, p 139). In comparing the Alvastra material with other Swedish Neolithic sites there are hardly any differences to be noted except for the tibia measurements and possibly the length of the M^3 from Gullrum both of which show the presence of smaller animals than seen at Alvastra. The measurements of the scapulae from the cave of *Stora Förvar* on the isle of *Stora Karlsö*, Sweden, also indicate the presence of smaller individuals. However, since the scapula material is not unambiguous due to the possibility of young individuals involved and it is possible that the material from *Stora Förvar* is not accurately dated (Ekman 1974, p 216), these differences may have minor importance. This may possibly be valid also for the differences noted in the material from Gullrum since, apparantly, there may be more recent bones also involved (Ekman 1974, p 219). On the other hand, comparing lengths of the lower third molar (M_3) Ekman states (1974, p 216, 219 and Fig. 3) that the Neolithic boar from Gotland differs in size from the smaller domestic pig from Bundsø but not from the ones from the Alvastra pile dwelling. Ekman (1974, p 216) also notes the occurence in the Alvastra material of one nearly intact mandible of pig which shows clear signs of domestication.

In comparison with the Alvastra material measurements of pig specimens from New Grange, Ireland, may also be considered. The bone material available from New Grange is dated to the Late Neolithic. The remains are stated to come from undoubtedly domestic pigs, although of large size, whose exterior appearance is assumed to have ressembled their wild ancestors (van Wijngarden-Bakker 1980, p 157, 165). It is noted that the measurements of M^3, tibia and also scapula indicate the presence of smaller animals, as well as ones up to the same size as in the Alvastra material (Tables 60–62). This conclusion is confirmed by the withers heights given by van Wijngarden-Bakker (1980, p 158) which vary from 68 cm to 82.8 cm using Teichert's formula, or from 74.4 cm to 83.2 cm, as calculated by me using Sjøvold's formula (Table 66).

To sum up, referring to the metrical results from Alvastra in comparison with dimensions from other Swedish and European sites of Neolithic and Mesolithic date it is argued here that some Alvastra dimensions probably indicate the presence of *pigs in an early stage of domestication* among the wild boar remains. This argument is based on the presence of M^3's and tibiae whose measurements fall below the known lower limits for wild boar (41 mm and 37 mm respectively) and also fall below the upper limits for domestic pig (40 mm and 35 mm respectively) used by Clason (1967, p 63). These dimensions and those of the

scapula and the ulna used by Clason (1967, p 63) are shown in Table 65. Furthermore, this argument is supported by the results from the calculations of withers heights which indicate the presence of smaller animals with withers heights of less than 80 cm and also of the fact that the pig remains from Bundsø, which are identified as fully domesticated pigs, in general seem to have come from smaller individuals than the ones from Alvastra.

In this respect it can be noted that five out of seven (70 %) of the pigs identified in the material from the Eastern Trench were young animals. It has not been possible to accurately identify the remains as belonging to wild boar. However, the fact that there are more juvenile than adult individuals represented in the material may indicate remains of domestic pigs. A wild sow does not voluntarily give up her piglets and is regarded as one of the most dangerous animals to hunt and kill. In addition the sows live in herds and help each other in situations of danger. Young animals can also count on help from older ones (Lieberkind 1937a, p 79–81).

When considering the possible domestication of a local, wild population the social behaviour of the species in question is of a great importance. For instance, it has been pointed out that it is the social structure of wild sheep which has enable the closer association between wild sheep and ourselves and similarly it is the social structure of red deer which makes a closer association impossible (Clutton-Brock 1981, p 51). The wild boar is a sociable animal. Moreover, it is not territorial. This makes it more susceptible to influence by man. Even if the adult wild boar is a ferocious animal the piglets can easily be tamed and fed, since the wild boar is an omnivore. This provides an ideal situation for the initial closer relationship between man and wild boar (Clutton-Brock 1981, p 73).

In Alvastra and its surrounding area it is possible that wild boar may voluntarily have sought out human settlements, being attracted to refuse dumps, especially during the cold winters. This may have facilitated the capture and taming of young animals by the Neolithic farmer and thus constitute the beginning of a domestication which later formed populations of so-called 'pigs in open pasture' (Lepiksaar 1973, p 148–149, 1977, p 91).

However, it is argued here that the conditions of life for groups of early domestic pig probably did not entirely exclude the possibility of their mating with wild boars. This may have contributed to the maintenance of 'wild' characteristics in the domestic stocks. Hence it is suggested that during the Neolithic conditions may have been suitable for the domestication of wild boar at Alvastra. It may well be that the remains of pig from the pile dwelling provide evidence that such domestication was taking place.

An attempt has been made, using the ages of the juvenile individuals in the material, to estimate at what time of the year they were killed. Again this is linked to the question of what time of year the pile dwelling was in use. The rutting period of wild boar begins in early November and lasts into December or even longer. The sow gives birth to her piglets in March –April time (Lieberkind 1937a, p 80, Siivonen 1976, p 127). It has been argued that the sow usually gives birth in April and only in exceptional cases in March or May (Aaris-Sørensen 1978, p 21). Accordingly, in the following estimations an approximate birth period is assumed from the beginning of April to the end of the month.

In view of this, it may be assumed that *Individual 7*, the youngest, was killed at the earliest in the middle of May or at the latest early in August. It is assumed that *Individual 6* was older than the former and most probably killed sometimes during the autumn. Using tooth eruption, size and wear of the teeth, as well as size and morphology of bone specimens *Individual 5* was probably older than seven months but younger than one year and was most probably killed in late winter or at the latest during early spring. Using the same criteria, *Individual 4* was larger and more strongly built than the former and thus probably a little older, possibly close to one year old. It may thus have been killed at the beginning of spring and at the latest by the end of spring. Considering *Individual 3*, the third upper molar has erupted but is not much worn. According to this detail and also the epiphyseal fusion stage of the long bones it is assumed that this animal was killed in late winter or at least by the end of spring/beginning of summer. The results of these evaluations are shown in Fig. 21.

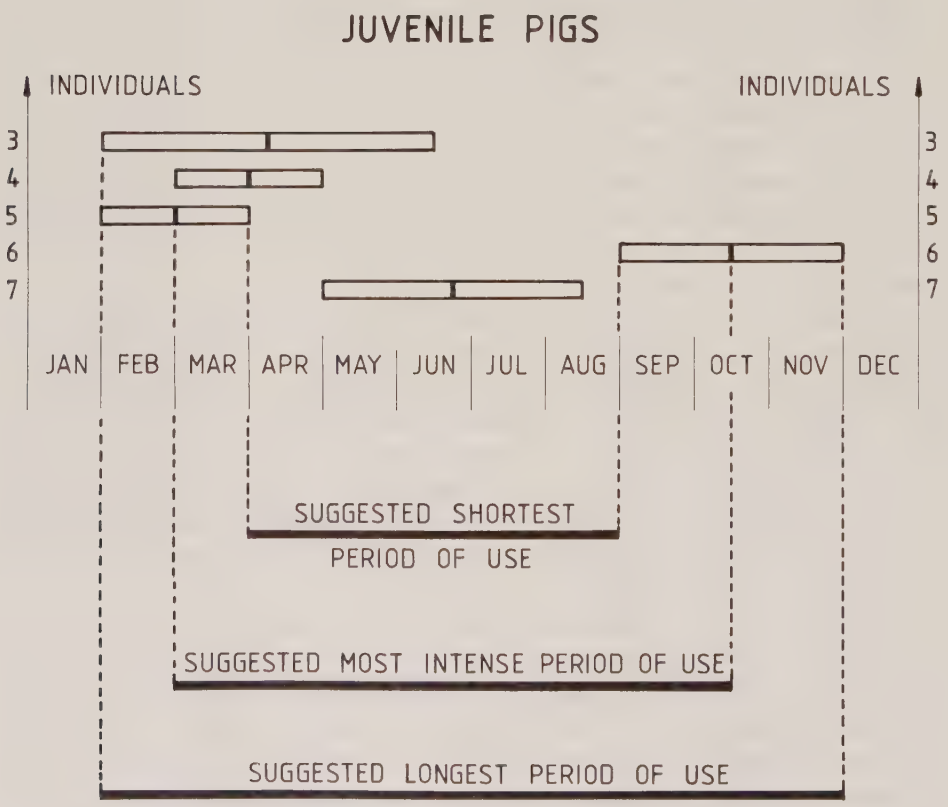

Fig. 21. Suggested SEASONAL USE of the pile dwelling with respect to the time of death for JUVENILE PIGS.

In view of these results it can be seen that the pile dwelling may have been used as early as the beginning of February until the end of November. In the case of each individual a mean value for the time of death has been estimated (Fig. 21). Perhaps the busiest time at the site are indicated by the time period which these mean values comprise, that is, from the beginning of March to the middle of October.

It may be concluded then that probably very little of the pig carcass was not used and that wild boar and early domestic pig played an important role as meat and fat producers in the life and economy of the Alvastra people. Use of skin and hog's bristle may have been important even though there is no archaeological evidence. It seems that for many years in old popular belief, wild boar hunting established social status giving the hunter considerable prestige (Brusewitz 1978, p 138). The tusks from wild boar, especially from males, were certainly attractive status symbols and tusks, incisors and fibulae were, among other specimens, used in the manufacture of ornaments and implements (Table 76). Besides being used as trophies the tusks were formerly considered to cure infections, such as a sore throat (Brusewitz 1978, p 140).

One skull fragment and one metatarsal show butchery marks (Table 77). As for the herbivores the degree of fragmentation of the bones is high which may indicate that fracturing of the bones were practised in order to get access to marrow and fat. There are 18 fragments which show marks of being gnawed and chewed by mammal teeth. The gnawed bone specimens represent all body regions (Table 78). Two fragments, one rib and one diaphysis of a fibula show marks of healed injuries which may originate from a fracture or possibly an ossifying haematoma (Baker & Brothwell 1981, p 87–89). There is evidence of repair with callus formation. Possibly there may also have been a slight inflammatory reaction (Fig.22).

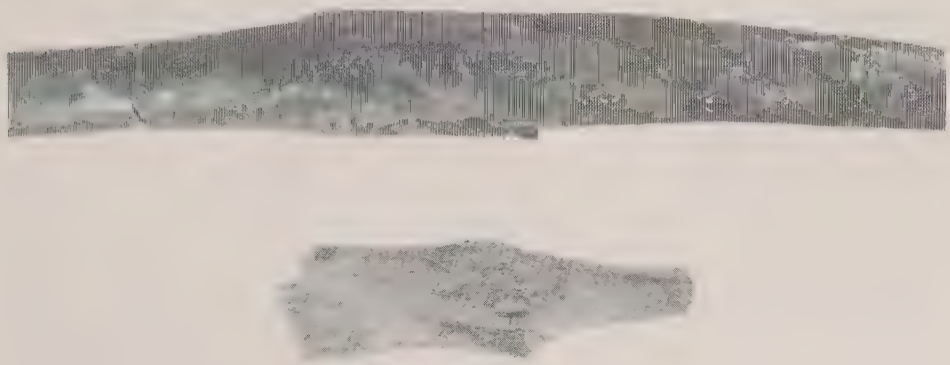

Fig. 22. PIG. 1. RIB and 2. FIBULA showing marks of healed injuries. Scale 1:1.

Table 60. **Wild boar** and/or **Domestic pig.** Measurements of M^3; maximum length (L) and breadth (B). Data in mm.

Locality	Age	M^3L	M^3B
1 Alvastra Eastern Trench	MN	38.2	21.3
2 Alvastra L. Hedell	MN	38.9	22.5
3 Alvastra J. Ekman	MN	36.1, 41.5 –	22.0, 19.0 22.4
37 Åloppe	MN	40.0–42.0	–
38 Gullrum	MN	34.0–39.0	21.0–24.0
40 Äs	MN	36.5–41.0	20.0–22.0
4 Cave *Stora Förvar*	N (mainly)	36.0–39.0	18.0–20.5
5a Troldebjerg	MN	32.0–36.7	
7 Bundsø	MN	29.0–38.0	17.5–21.0
8 Lidsø	MN	32.0	18.5
9 Ørum AA	MN	34.5–37.5	–
10 Aalborg	MN	29.5–37.5	
12 Aamosen	MES-MN	35.0–44.2	20.8–23.4
13 New Grange	LN	29.1–37.8	15.0–22.0
41 Kvarnby	IA	30.0–32.0	18.0–20.0
Boberget	IA	33.0	19.0
17 Vejleby	IA	28.0, 33.0	–
21 Lund	1020–1400	28.0–30.0	–
42 Uppsala	1000–1600	23.0–30.0	15.0–18.0
43 Bog sites, Scania (wild boar)	–	40.0–44.0	21.5–24.0
44 Segerbro, Arlöv I (wild boar)	MES	43.5–44.7	–
45 MNH, Gothenburg (coll. of modern wild boar)		34.5–38.0	–

Table 61. **Wild boar** and/or **Domestic pic.** Measurements of the **Scapula;** min. length of the neck (SLC), max. length of the glenoid process (GLP), length of the glenoid cavity (LG) and breadth of the glenoid cavity (BG). Measurements of the **Ulna;** max. length (GL), depth across the processus anconaeus (DPA), max breadth across the coronoid process (BPC) and length of olecranon (LO). Data in mm.

		Scapula				Ulna			
Locality	**Age**	**SLC**	**GLP**	**LG**	**BG**	**GL**	**DPA**	**BPC**	**LO**
1 Alvastra Eastern Trench	MN	–	36.7	32.5	28.8	268.9	56.2	26.5	82.7
2 Alvastra L. Hedell	MN	36.0	–	36.5	32.0	–	45.5	–	–
3 Alvastra J. Ekman	MN	27.8, 29.2, 29.9	–	–	–	245.0	–	24.6, 21.0, 23.1, 26.6	–
37 Åloppe	MN	36.0	–	36.0	32.0	–	–	–	–
38 Gullrum	MN	27.0–31.0	–	31.0–36.0	26.0–31.0	–	–	–	65.0–73.0
39 Ringsjön	MN	27.0–32.0	–	30.0–35.0	26.0–30.0	–	–	–	–
40 Äs	MN	27.0–29.0	–	–	–	–	–	–	–
4 Cave *Stora Förvar*	N (mainly)	25.0–28.0	–	26.0–33.0	23.0–28.0	–	–	–	60.0
7 Bundsø	MN	22.0–28.0	33.0–41.0	26.0–35.0	24.0–31.0	–	–	–	–
8 Ørum AA	MN	28.5	–	–	–	–	–	–	–
9 Aalborg	MN	25.0–27.0	–	–	–	–	–	–	–
10 Leire AA	MN	25.0	–	–	–	–	–	–	–
13 New Grange	LN	17.6–28.0	–	–	–	–	–	–	–
19 Eketorp II	400–700	20.3–26.3	28.4–40.3	25.2–33.9	–	–	–	–	–
20 Eketorp III	1000–1300	17.0–25.5	25.9–36.7	21.9–31.5	–	–	–	–	–
21 Lund	1020–1400	18.0–26.0	–	–	–	–	–	–	–
46 Switzerland, Bayern (subfossil wild boar)		31.0–37.0	–	36.0–39.0	32.0–35.0				

Table 62. **Wild boar** and/or **Domestic pig.** Measurement of the **Tibia;** max. breadth of the distal end (bd). Measurement of the **Patella;** max. length (GL) and max. breadth (GB). Data in mm.

Locality	Age	Tibia Bd	Patella GL	Patella GB
1 Alvastra Eastern Trench	MN	32.1, 37.4	41.4	24.2
2 Alvastra L. Hedell	MN	33.0, 33.7, 34.8, 35.7, 35.8, 38.7, 42.5	43.0	26.0
3 Alvastra J. Ekman	MN	33.5, 33.9, 34.8, 35.6	–	–
38 Gullrum	MN	27.0–37.0	–	–
39 Ringsjön	MN	32.0–34.0	–	–
4 Cave *Stora Förvar*	N (mainly)	34.0–36.0	–	–
7 Bundsø	MN	31.0–32.0	–	–
12 Aamosen	MES-MN	33.6, 34.0, 36.0.	–	–
13 New Grange	LN	27.8–36.5	–	–
19 Eketorp II	400–700	25.7–32.1	–	–
20 Eketorp III	1000–1300	22.8–34.1	–	–
21 Lund	1020–1400	26.0–31.0	–	–
48 Sweden (wild boar)	MES	34.0, 35.0	–	–
49 Switzerland (wild boar)	N	33.0–42.0	–	–
45 M N H, Gothenburg (coll. of modern wild boar)		34.0, 36.0	–	–

Table 63. **Wild boar** and/or **Domestic pig.** Measurements of the **Talus;** max. lateral length (GL1) and max. medial length (GLm). Measurements of **Metatarsals** (Mc II, Mt III, Mt IV) and **Metacarpal** (Mc V); max. length (GL). Data in mm.

Locality	Age	Talus GL1	Talus GLm	Mt II GL	MT III GL	MT IV GL	Mc V GL
1 Alvastra Eastern Trench	MN	39.5	36.6	72.5	–	–	–
2 Alvastra L. Hedell	MN	46.5, 48.7, 49.5,	–	67.4	95.0	71.5	69.5
3 Alvastra J. Ekman	MN	45.2, 48,2 46.5, 49.0, 46.9, 49.3, 48.0, 49.4	– – – – – – – –	–	–	107.0	–
37 Åloppe	MN	48.0	–	–	–	–	72.0
38 Gullrum	MN	42.5–50.0	– –	67.0–77.0	–	–	64.0
39 Ringsjön	MN	45.0–50.0	–	–	–	–	–
47 Ånneröd, Rörvik	Mn	52.0, 54.0	–	–	–	–	–
48 Äs	MN	45.0–52.0	–	–	–	–	–
4 Cave *Stora Förvar*	N (mainly)	37.0–49.0	–	64.0	89.0	94.0–99.0	65.0
7 Bundsø	MN	41.0–46.0	–	–	–	–	–
9 Ørum AA	MN	47.0	–	–	–	–	–
12 Aamosen	MES-MN	44.6–56.0	–	–	–	–	–
13 New Grange	LN	38.3–46.3	–	–	–	–	–
19 Eketorp II	400–700	36.1–42.1	32.6–38.0	–	73.5	77.5–88.0	–
20 Eketorp III	1000–1300	33.3–43.2	30.7–39.5	54.0	74.0–78.5	74.0, 77.0	45.4–47.5
21 Lund	1020–1400	34.5–42.5	28.5–34.5	–	–	101.0	–
48 Sweden (wild boar)	MES	43.7–56.0	47.0	–	–	–	–
45 M N H, Gothenburg (coll. modern wild boar)		44,0, 51.2	–	–	–	–	–

Table 64. **Wild boar** and/or **Domestic pig.** Measurements of **Phalanx I, Phalanx II** and **Phalanx III** of Metapodials III/IV and II/V (PH I (III/IV), PH I (II/V), PH II (III/IV) and PH III (II/V)); max. length of the peripheral half (Glpe), max. length (GL) and max. diagonal length of the sole (DLS). Data in mm.

Locality	Age	PH I (III/IV) Glpe	PH I (II/V) Glpe	PH II (III/IV) GL	PH II (II/V) GL	PH III (III/IV) DLS	PH III (II/V) DLS
1 Alvastra Eastern Trench	MN	47.7	24.5	26.8	11.8	31.8	15.9, 18.9, 22.1, 22.5
2 Alvastra L. Hedell	MN	33.0, 43.7, 44.0, 46.0, 47.0	–	27.0, 28.0, 29.0, 29.0	–	33.0, 37.5	–
3 Alvastra J. Ekman	MN	37.5, 43.0, 43.5, 44.7, 45.0, 46.8, 47.4, 58.2		–	–	–	–
37 Åloppe	MN	–	23.0–30.0	24.0–27.0	12.0–14.0	29.0–35.0	17.0–21.0
38 Gullrum	MN	38.0–45.0	22.0–28.0	22.0–29.0	13.0–15.0	28.0–33.0	15.0–23.0
4 Cave *Stora Förvar*	N (mainly)	37.0–43.0	–	22.0–27.0	–	31.0–33.0	–
12 Aamosen	MES-MN	45.0–50.5	–	–	–	–	–
19 Eketorp II	400–700	31.5–40.8	–	16.5–24.6	–	–	–
20 Eketorp III	1000–1300	25.9–37.9	–	15.5–24.9			
21 Lund	1020–1400	35.0–36.0	–	21.0–30.0	–	–	–

Table 65. Dimensions used by Clason (1967, p 63) in the positive identification of either wild boar or domestic pig.

Element and **Measurement**	**Wild boar**	**Domestic pig**
M^3 max. length (L)	41–50	23–40
Scapula, height of the neck (SLC)	29–36	13–29
Ulna, width of facies artic. (BPC)	26–30	16.–25
Tibia, distal width (Bd)	37–43	24.–35

Table 66. **Withers height** for **Wild boar** and/or **Domestic pig.** The estimations are based on measurements of the Ulna (GL), Talus (GL1) and Metatarsals III and IV (GL) given in Tables 63 and 65. The formulae for determination of height are for Ulna: 2.73(x) + 28.9 ± 3.0; for Talus: 10.92(x)+32.6 ± 2.8; for Mt III: 7.52(x)+22.5 ± 2.4; for Mt IV: 6.59(x) + 25.95 ± 2.5; where x is the bone length in cm (Sjøvold, 1986). The factors given by Teichert (1969, Table 7) for corresponding estimations are: 3.97, 17.90, 9.34 and 8.84. All data are given in cm. Sjøvold (T.S.), Teichert (M.T.)

		Ulna		Talus		Mt III		MT IV	
Locality	**Age**	**T.S.**	**M.T.**	**T.S.**	**M.T.**	**T.S.**	**M.T.**	**T.S.**	**M.T.**
Alvastra Eastern Trench	MN	102.3	106.8	75.7	70.7	–	–	–	–
Alvastra L. Hedell	MN	–	–	83.4, 85.8, 86.7	83.2 87.2 88.6	93.9	88.7	73.1	63.2
Alvastra J. Ekman	MN	95.8	97.3	82.0– 86.5	80.9– 88.4	–	–	96.5	94.6
Åloppe, Gullrum, Ringsjön	MN	–	–	79.4– 87.2	76.1– 89.5	–	–	–	–
Ånneröd, Rörvik	MN	–	–	89.4, 91.6	93.1, 96.7	–	–	–	–
Äs	MN	–	–	81.7– 89.4	80.6– 93.1	–	–	–	–
Cave *Stora Förvar*	N (mainly)	–	–	73.0– 86.2	66.2– 87.7	89.4	83.1	87.9– 91.2	83.1– 87.5
Bundsø	MN	–	–	77.4– 82.8	73.4– 82.3	–	–	–	–
Ørum AA	MN	–	–	83.9	84.1	–	–	–	–
Aamosen	MES-MN	–	–	81.3– 93.8	79.8– 100.2	–	–	–	–
New Grange	LN	–	–	74.4– 83.2	68.6– 82.9	–	–	–	–
Eketorp II	400–700	–	–	72.0– 78.6	64.6– 75.4	77.8	68.7	77.0– 83.9	68.5– 77.8
Eketorp III	1000–1300	–	–	69.0– 79.8	59.6– 77.3	78.1– 81.5	69.1– 73.3	74.7, 76.7	65.4, 68.1
Lund	1020–1400	–	–	70.3– 79.0	61.8– 76.1	–	–	92.5	89.3
Segebro, Arlöw I (wild boar)	MES	–	–	80.3– 93.8	78.2– 100.2	–	–	–	–

7.1.7 Wolf (Canis lupus)

The wolf thrives well in forest regions both in flat country and in mountainous districts, especially if there are large marshlands and dense thickets. Its food consists of larger mammals such as cervids and bovids, as well as all kinds of small rodents, hares and gallinaceous birds and at times even carrions. If there are refuse dumps around they may well attract the wolf. The wolf is mainly active during the night. It can move over large areas fast and resolutely and is a good swimmer. At the same time it is both a solitary and gregarious animal. It lives alone or in pairs during spring and summer. When the fall arrives it joins small packs, although these can merge during the winter for hunting purposes. In social behaviour the wolf shows, like man, a complex pattern. The social structure is based on a hierarchical system which ranks the members in dominant and submissive roles. This was the key factor which made it possible for the taming of the wolf and the eventual domestication which gave rise to the dog. It also made possible the development of bonds of affection between man and dog. The mating season starts at the end of December and lasts at least a couple of months. The female gives birth to a litter of four to six cubs in April–May time. She takes very good care of her pups and if she feels threatened she moves the whole family (Lieberkind 1939a, p 162–165, van den Brink 1958, p 131, Siivonen 1976, p 108, Clutton-Brock 1981, p 34, 36).

Large forest regions, open areas alternating with shubbery, fen lands and watercourses within the Alvastra resource area provided the wolf with a good habitat which was rich in prey animals. Nevertheless, the remains of wolf are few in the material from the Eastern Trench. This is also the case in earlier analyses of bone material from the pile dwelling referred to (Table 31). The wolf should have been a strong competitor with the human group for desirable game. The wolf was certainly a serious threat to the livestock and may also have been something of the threat to people. Down to the present time in Sweden people seem to have feared and hated the wolf. In the Nordic medieval laws the wolf is considered an outlawed animal. Instead of calling the wolf its right name people used paraphrases, such as *gråben, ulf* and *tasse* and the words *varg i veum* mean outlawed. Probably brown bear and lynx were not, in general, an equal source of danger to man and the domesticates around him. Since there are often at least a couple of wolves hunting together the devastation can be great when they attack cattle and sheep for instance. Furthermore, the wolf is rapacious and may often kill more prey than it needs to appease hunger (Ekman 1910, p 107–110, Lieberkind 1939a, p 163, Brusewitz 1978, p 182, Lepiksaar 1982, p 113).

In the ecological system existing at Alvastra during the Middle Neolithic both man and wolf were at the top of the nutritional chain. In the case of hunting capacity they were to be considered as competitors. However, man had a great advantage – the benefit of the dog.

The wolf attains a withers height of 70 cm up to 90 cm, a body length between 100 and 140 cm and a weight mainly between 20 and 55 kg, although sometimes a male can weigh up to 75 kg (van den Brink 1958, p 131, Siivonen 1976, p 107).

It seems likely that the relatively low frequency of wolf bone material from the site may depend on reasons other than a less favourable biotope with accordingly a smaller population of wolves in the area. The low frequency may depend for example on human selection before animal bodies were brought to the site. It may also indicate the capacity of the wolf to defend itself (Lepiksaar 1983, p 143), making this animal not a common human prey but one which demanded a great deal of hunting and effort to kill.

Possibly wolf hunting was a matter of great importance, giving the hunters high status and prestige. Wolf may also have provided humans with a warm and hardwearing fur coat. The pelt has its best quality during the winter season (Bjärvall, pers. comm.). The presence in the material of, originally, probably whole metacarpals, slightly damaged by fire, may indicate that they had been left, dried and assembled articulating in a wolfskin, which in turn had been damaged by fire. A wolf paw could also have been used as a talisman, and this could also have been the case with body parts from other important and dangerous species. Taking human cultural habits into consideration, it is further possible that at times wolf meat might have been ritually consumed.

None of the fragments show distinct butchery, skinning or gnawing marks. Moreover, there is no evidence of pathological change on the fragments.

Table 67. **Wolf.** Measurements of **Metacarpals** (Mc II, Mc V); max. length (GL). Measurements of **Phalanx II;** max. length (GL), max. proximal (Bp), max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Damaged by fire (dbf). Data in mm.

		Mc II (dbf)	Mc V (dbf)	Phalanx II (burnt*)			
Locality	**Age**	**GL**	**GL**	**GL**	**Bp**	**Bd**	**SD**
1 Alvastra Eastern Trench	MN	88.7	–	17.4	7.0	7.0	6.4
2 Alvastra L. Hedell	MN	–	78.7	–	–	–	–
3 Alvastra J. Ekman (wolf?)	MN	–	78.0	–	–	–	–
12 Aamosen	MES-MN	89.5	–	–	–	–	–

* According to von den Driesch (1976, p 3) on average 15 % of the size is lost.

7.1.8 Dog (Canis familiaris)

The dog of the Middle Neolithic was a product of a long period of domestication. The process of taming probably began more than 12000 years ago and the first discovery of a domestic dog came from Palegawra in Iraq and is dated to late Palaeolithic times, about 12000 B.P. It is currently believed that the wolf is the progenitor of all kinds of dog domesticated by prehistoric human hunters

(Clutton-Brock 1981, p 34, 42). In Europe the earliest finds of dog are dated to the Mesolithic and come from Star Carr in England, Zealand settlements in Denmark, Pulli in Estonia and Bua Västergård in Sweden (Degerbøl 1933, p 588–594, Lepiksaar 1982, p 117, 1983, p 142). Lepiksaar (1982, p 117) states that the Swedish Mesolithic dog has a prehistory that begins about 8000 years ago. In this relationship between man and other species, the dog holds a unique position and a remarkable relationship has certainly developed. Without doubt, it would have answered the needs of hunting teams and perhaps was initiated when wolf pups were caught and reared within the human community. The dog has a keen sense of smell. This was probably of invaluable help to prehistoric man when stalking and hunting various game animals and also other beasts of prey. The dog was further of considerable value in tending both cattle and sheep. Its barking also warned people against approaching dangers. The propensity of barking is a consequence of domestication and was never well developed in wild canids (Clutton-Brock 1981, p 37–39, Lepiksaar 1983, p 142). Since Mesolithic times man seems to have used the dog ritually and also treated him with honour and affection and in Sweden there are finds of dog burials since this time period (Møhl 1962, p 904–905, Larsson 1980, p 32–33, 1981 p 33–34, 1982, p 15, 1983a, p 26–28, 1984, p 66–67). It has however been argued that the living conditions for 'man's best friend' were not always as pleasant and comfortable as they should have been. Marks of old fractures have been noted on prehistoric dog skulls, including from the Middle Neolithic (Hatting 1978, p 197). It seems likely that such marks originate from rough handling by humans.

More than 300 bone fragments from the Eastern Trench show marks indicative of being gnawed and scored by mammal teeth. (Table 5 and 78). Several marks may have come from the activities of dogs. If so, then the dogs seem to have enjoyed their meals, scavenging and probably scattering the bone remains! The remains of dog are however very few in the Eastern Trench material. They are also generally scarce both in the published and unpublished results from earlier analyses (Table 31) and this is stressed by Hedell in his notes. The teeth of the dogs, however, were kept and used as ornaments (Table 76).

The constantly small proportion of dog remains in all bone samples from the site may reflect the actual situation. The dog is unlikely to have been an animal which was brought to the pile dwelling to be either consumed or skinned for its coat. It is possible that it may have been used for ritual or other activities. It is however argued that the dog was most of all important to man alive, and that dead bodies of dogs may have been honoured and buried or at least in general covered up elsewhere to avoid scavengers. Moreover it is likely that dogs, as well as other animals, just visited the pile dwelling looking for food remains, especially when there were no people around.

On the fragments there are no distinct marks of gnawing or butchering. Neither are there any evidences of pathological changes.

7.1.9 Brown bear (Ursus arctos)

The brown bear has a predilection for deep forests and also hilly regions. It is, however, tolerant of varying habitats and is not tied to one biotope. This means that it may range over vast areas. The brown bear is an omnivore, with plant foods such as herbs, roots, hazelnuts, bilberries and cloudberries being an essential part of the diet. This diet is varied with ants, honey, other insects, larvae and various small mammals. It may also kill and eat larger mammals such as deer and cattle, as well as scavenging from kills by other predators. Primarily the brown bear is active during the twilight and night. When it moves it is both fast, mobile and lithe and climbs about on hillsides and even in trees. Moreover, the brown bear enjoys water and is a good swimmer and as a result can sometimes catch fish. Considering its social behaviour the brown bear is not gregarious. It lives in general alone and is an anti-social and cautious animal. Towards the end of the autumn the brown bear goes into hibernation where it stays until spring. However, the sleep is not too heavy and the brown bear may leave the hibernation-den if there are mild weather periods. At the end of January or beginning of February the female gives birth to one or two at times four cubs which she takes good care of. Such cubs are totally defenseless since they are only about 20 cm in length and blind when they are born. The young bears may stay with their mothers a fairly long time – up to two years (Lieberkind 1939a, p 234–235, van den Brink 1958, p 138, Siivonen 1976, p 111).

In the forests and hilly areas within the Alvastra region the brown bear may well have found favourable habitats where it could thrive. In the bone material from the Eastern Trench the remains of brown bear are few. In the results of earlier analyses of bone material from the site the remains may vary from being totally absent to a few specimens or up to more than 20 (Table 31). This indicates that the brown bear may be better represented and have a higher relative frequency overall among identified material than the remains from the Eastern Trench suggest. Possible reasons for a varying distribution of the bear remains is discussed elsewhere (Section 7.1.4).

The brown bear cannot really be considered to have been a competitor with man at Alvastra for food. However, in the spring, summer and fall it could have caused a lot of harm and danger by attacking cattle and sheep (Ekman 1910, p 84). Within the ecosystem of this area the brown bear probably held the highest survival position of any mammal species (Bjärvall, pers. comm.). Its worst enemy was, without doubt, man who could well have found it attractive for fur, meat and fat. In Sweden, since time immemorial, the bear hunt has had prestige and high social status. Even if the bear is not in general a ferocious animal it certainly has superior strength and is a dangerous adversary, especially if injured and enraged. Nevertheless, the brown bear has never been the object of fear and hate as the wolf, but has rather been an object of cult rites, as for instance among the Laplanders (Lieberkind 1939a, p 237, Brusewitz 1978, p 163).

The modern brown bear of Europe attains a withers height of 90–125 cm and may attain a body length of 2.5 m. The body weight may vary from 100 to 300 kg (van den Brink 1958, p 138, Siivonen 1976, p 110). The carcass weight for

Swedish Mesolithic brown bears has been estimated at 50–150 kg (Larsson 1978, p 189).

It has been argued (for example by Degerbøl 1933, p 467–569) that the subfossil remains of both Swedish and Danish brown bears indicate the presence of larger individuals than do recent remains of this species existing in Sweden and Norway today. Degerbøl (1933, p 481) further points out that the size of the teeth may vary considerably, that is, large animals may have small teeth and vice versa. Measurements are given in Tables 68 and 69. In general it can be said that, besides age and sexual dimorphism, the size of the brown bear, as for other mammals, depends on geographic and nutritional factors. During Holocene times, human groups have gradually driven away or eliminated wild species from areas of high food value, restricting them to poorer conditions and geographic isolation. As a rule the wild mammals are of a larger size in northern and could areas. The biomass increases as a response to keep warm and often so does the space for these species. Among the brown bear remains from the Eastern Trench one ulna was measured. By comparison with recent material this specimen seems to have come from a large animal and in fact it has about the same length as an ulna from a grizzly bear (Table 68).

It seems likely that the brown bear remains in bone material from the pile dwelling may indicate that this animal had been hunted fairly regularly and providing a considerable amount of meat, as well as skins for domestic use. Also, the bear's gall had formerly a large field of application therapeutically and was for example considered by the Laplanders to be a very important medicine against internal illnesses (Ekman 1910, p 85). The winter pelt of the brown bear is thicker and more longhaired, giving a warmer fur of higher quality, and this hair quality may remain until the beginning of May (Bjärvall, pers. comm.). Hunting the brown bear from late autumn into spring thus offered the best pelts. However, tracking down hibernation-dens is not easy work (Bjärvall, pers. comm.). Moreover, during the cold sub-boreal winters the brown bear probably hibernated over long periods. Consequently, even if hibernation can be said to facilitate the hunt in some ways (Ekman 1910, p 62–72, Lieberkind 1939a, p 242, Lepiksaar 1983, p 143) and the hunters had skis, it can be argued that hunting during the deep winter would not have been undertaken too often. Considering these various factors, brown bear hunting may very well have taken place as much in the summer season.

The ulna is complete and does not show any cut marks or other marks or changes. Whole and undamaged long bones from meat producing mammals seem to be rarely found among the bone remains from the pile dwelling. This ulna was found close to one of the hearths and in association with two small oblique flint arrowheads, perhaps a testimony to a cermonial after successful hunting.

Table 68. **Brown bear.** Measurements of the **Ulna;** max. length (GL), depth across processus anconaeus (DPA), max. breadth across the coronoid process (BPC), max. distal breadth (Bd), max. proximal diameter (PD), inner diameter of the semilunar notch (SD). PD and SD are defined by Kurtén (1964, p 11–12). Data in mm.

Locality	Age	GL	DPA	BPC	Bd	Pd	SD
1 Alvastra Eastern Trench	MN	373.1	57.2	50.0	40.9	66.6	33.0
50 Sturefors (subfossil)		302.0	–	–	–	54.7	27.4
51 Dyrhøjgårds mose	MES	360.0	59.5	55.0	–	66.5	34.0
52 Galtrup Kaer (uncertain age)		416.0	63.5	61.0	–	74.0	42.7
53 M N H, Gothenburg (coll. modern brown bear)		284.4–356.2	47.3–54.1	41.7–50.4	30.4–39.7	49.7–63.5	–
54 M N H, Gothenburg (modern grizzly, *Ursus sitkonsis)*		374.6	69.2	61.7	44.3	74.0	–
55 M N H, Stockholm & D of Z, Stockholm & Uppsala (modern brown bear)		252.0–340.0	–	–	–	45.9–61.0	24.3–20.7 (30.2?)

Table 69. **Brown bear.** Measurements of **Teeth;** P_1, max. length (L), max. breadth (B), P_4, max length (L), max breadth (B) and M_3, max. length (L), max. breadth (B). Very worn (vw), alveolar dimension (ad). Data in mm.

		P_1		P_4		M_3	
Locality	**Age**	**L**	**B**	**L**	**B**	**L**	**B**
1 Alvastra Eastern Trench	MN	5.9	3.9	11.7	7.0	19.6 vw	15.5vw
56 Sweden (subfossil)		–	–	15.0ad	–	25.0, 26.0	17.0, 18.2
57 Denmark (subfossil)		–	–	10.6–15.0	6.5–8.7	18.0–25.0	15.0–17.8
58 Norway (modern brown bears)		–	–	10.5–14.2	6.0–8.5	15.5–22.0	13.0–17.0

7.1.10 Badger (Meles meles)

The badger thrives best in mixed forest regions both in flat country and in mountainous areas and also has a predilection for arable land. It is an omnivore which sleeps during the day leaving its set at sunset to look for food. Its main food consists of invertebrates, such as earth-worms and insects. It can plunder wasp's nests for larvae without getting hurt since the coarse pelage protects against stings.

During the nocturnal excursions it can also eat small mammals, birds, frogs and lizards. The badger is capable of climbing up trees but not high ones. In springtime it likes to feast on birds' eggs and nestlings. It also eats cereals and juicy roots of herbs and in the autumn berries, acorns, mushrooms and windfalls. The badger does not move far, preferring the same habitat. In terms of its social behaviour it is both solitary and gregarious. Even living within a group, however, the badger manages by itself. At the end of the autumn, by the first snowfall, the badger goes into hibernation in its set where it stays until the spring. Its sleep is not heavy and if the badger is disturbed or if the winter is mild it may leave the set looking for food. The only time of the year males and females form couples is during the mating season in October. Then they separate and hibernate alone in the sets. The cubs, usually two or three but sometimes up to five, may be born from the beginning of the spring until May and stay with their mother the whole summer or for a longer time. Lieberkind 1939a, p 297–298, van den Brink 1958, p 142, Siivonen 1976, p 118, Neal 1977).

Within the surrounding biotope of Alvastra and its ecological system conditions of life for the badger must have been extremely good. There were arable lands, mixed deciduous forest with glades, clearings and luxuriant ground vegetation providing an abundant resource of animal and vegetable food. There was Omberg providing hilly slopes and erratic blocks and shrubbery where it would have been easy to find suitable places for building sets. Wild apple-trees, still growing in the area, would have provided fruit for both humans and the badger. Also human refuse would have been a temptation for the badger, as for pigs.

According to the results from the Eastern Trench badger together with pine marten have a high relative frequency among the remains of fur animals. The results from earlier analyses of bone material from the pile dwelling show that the badger has the highest frequency among the identified remains of fur animals (Table 31). This indicates that the species was important to Middle Neolithic communities and was brought regularly to the site. It could in fact be said that the badger was an ideal prey, since it stays in the same habitat. Moreover, badger hunting was not dangerous for human groups as hunting large predators was. It should be noted, however, that a badger which has become enraged may give quite nasty bites, since the badger will not let go once it has got its teeth into a victim (Brusewitz 1978, p 241, Englund, pers. comm.). The badger is attracted to cereals and may therefore have done harm by trampling and destroying crops. Besides being hunted by man it had other potential enemies, such as the brown bear, wolf and lynx (Ahnlund, pers. comm.). However, these predators are unlikely to have seriously threatened the badger population in the ecosystem. If a badger population becomes too great for a habitat it seems that intrinsic factors control the number (Neal 1977, p 269). The wild boar and possibly the red fox *(Vulpes vulpes)* have to be considered as potential competitors for food (Lepiksaar 1982, p 118). The badger, however, thrives in general better in dryer areas, while the wild boar has a predilection for marshlands (Lepiksaar 1983, p 142). Hence it is suggested that in the Alvastra environment there was plenty of room for badger and these other species and that there was no serious competition in the actual

ecosystem. Regarding the red fox there are no remains identified to this species, neither in the bone material from the Eastern Trench nor in the bone material from earlier analyses which are referred to in this context (Table 31). This does not mean that the red fox did not exist in the region during Middle Neolithic times. Remains of red fox have in fact been identified in bone material coming from a Megalithic tomb of the same time period and situated less than 2 km WSW of the pile dwelling thus indicating that it had lived in the region at that time (During 1983, p 184). In this connection it may further be noted that other mammals often make use of the spacious badger sets in one way or another. Some are just casual visitors such as the pine marten, while for instance the red fox is a true commensal and occasionally wolves may use unoccupied sets as refuges (Neal 1977, p 103).

The live weight of the modern badger may vary from about 5 kg up to more than 20 kg. The withers height is about 30 cm and the body length between 60 and 90 cm (van den Brink 1958, p 142, Siivonen 1976, p 117). Like the two other omnivores, the wild boar and brown bear, the badger produces meat rich in fat. In the fall this species prepares for the hibernation by intensive eating and attains its greatest weight during this time period (Lieberkind 1939a, p 298, Lepiksaar 1983, p 142).

Considering available measurements taken on teeth and jaw specimens from the pile dwelling they show some variation in size between individuals, probably in general due to sexual dimorphism (Tables 70 and 71). The few comparable measurements from other Swedish subfossil badgers do not differ from the Alvastra specimens (Tables 70 and 71). The dimensions seem to fall within the range of measurements for Danish and Baltic subfossil badgers (Tables 70 and 71). In Denmark the subfossil badger seems to have been of a smaller size than the recent one considering dimensions of teeth, crania and mandibles. The recent Danish badger is in fact regarded as a special subspecies *(Meles meles danicus)* (Degerbøl 1933, p 576). The recent Baltic badger seems also, on the evidence on tooth and jaw dimensions, to attain a large size (Table 70). In the case of the Swedish subfossil and recent badgers the few dimensions which can be compared do not in fact indicate any size differences (Tables 70 and 71). The material, however, is far too small to make it possible to draw any distinct conclusions concerning possible changes in size of the Swedish badger through time.

It is in general claimed (for example Lepiksaar 1982, p 118) that the badger was hunted in prehistory to provide meat and possibly also fur. The winter pelt is the best quality, providing a coarse but hardwearing fur (Ahnlund, pers. comm.). However, the badger provides another valuable asset, animal fat. The fat lies under the skin and is concentrated to the hind part of the animal's back. It is easily melted down to fluid oil. As much as 5 kg of a badger with a weight of 15–18 kg may consists of fat (Ahnlund, pers. comm.). The fat does not smell and was formerly used as an excellent shoe polish (Ahnlund, pers.comm.) and also therapeutically, for example in connection with rheumatism (Neal 1977, p 29). For prehistoric communities, therefore, badger fat was probably highly attractive and more valuable than the rather coarse pelt.

Consequently the most profitable hunting, as to both meat and fat, is likely to have taken place during late summer and above all in the autumn, when the animals were fattest. Since the badger, like the brown bear, usually passed the winter hibernating, accessibility during this season was small. Today, the hunting of badger in winter does not usually occur (Ahnlund, pers.comm.). At times, perhaps especially in the fall, the badger could have been hunted as a nuisance if it was causing damage, feeding on crops. The remains of badger from the Eastern Trench show further that long bones, for instance tibia and ulna, were attractive in manufacturing bone implements (Table 76).

None of the fragments shows any distinct marks of skinning and butchering. On the other hand there are no whole bone specimens found among the remains besides teeth, one talus and one third phalanx. Like other meat producing animals the bones have probably been damaged in connection with food preparing and consumption. But there are neither distinct gnawing nor biting marks on the bones.

One mandibular half shows a dental anomalie and changes. The first premolar (P_1) is missing (probably not developed). However, this is not especially unusual among badgers (Winge 1908, p 139). There is also a loss of the carnassial (M_1) which seems to have been broken off ante-mortem. Nevertheless the distal root still remains in the jaw. The other alveoli exhibit bone remodeling with the formation of a lingually directed, partly fairly sharp torus (Fig. 23). Since the tooth is missing it is not easy to determine the cause of the injury. There may have been trauma with chronic irritation and inflammation of the gum area as the result. This may then has healed without exposing the jaw to any further process of infection. The reason may also have been caries (Baker & Brothwell 1980, p 145–157). In the case of caries it is to be noted that Hedell, in the bone material from 1919, observed caries on two teeth (P_4 and M_1) in the same jaw (Hedell 1919). Caries seems to be very common among modern Swedish badgers (Ahnlund, pers.comm.).

Fig. 23. BADGER. MANDIBLE showing dental anomalie and other changes. Scale 1:1.

Table 70. **Badger.** Measurements of **Teeth** and the **Mandible;** P_4, max. length (L) and max. breadth (B), M_1, max. length (L), length of the aboral border of the alveoli (AL) of C-M_2, P_2-M_2 and height of the mandible behind M_1 (HbM_1). Alveolar dimensions (ad). Mean value ($\bar{x}$). Numbers (n). Data in mm.

Locality	Age	P_4 L	P_4 B	M_1 L	C-M_2 AL	P_2-M_2 AL	HbM_1
1 Alvastra Eastern Trench	MN	7.4	4.0	–	40.6	38.5	16.0
2 Alvastra L. Hedell	MN	–	–	13.5, 14.4, 15.1, 15.3, 15.4, 15.8 (n=26)	–	37.8? 39.0 – – – – (n=15)	14.0, 13.5, 14.0, 13.0, 14.2, 12.7
3 Alvastra J. Ekman	MN	–	–	14.3–17.4 $\bar{x}$15.6 ±0.9 (n=21) 13.7–16.1 ad $\bar{x}$14.8 ±0.7	38.3, 38.5, 39.2, 39.2, 39.4 39.8, 40.2, 40.7, 41.6, 42.2, 43.0	36.4–40.4 $\bar{x}$37.8 ±1.6	14.9, 16.9
40 Äs	MN	–	–	–	–	36.3	–
62 Estonia	Sub-bor	–	–	14.0–17.0	–	38.0–42.0	–
12 Aamosen	MES-MN	6.5, 6.7	4.2, 4.2	15.5–16.4	–	40.5, 41.5	16.2 17.0
60 Denmark	MES	6.5–7.3	3.7–4.2	14.3–18.5	38.5–44.5	–	14.2–18.0
62 Estonia	MES	–	–	15.0–17.0	–	37.0–43.0	–
63 Sweden (modern badger)		–	–	15.4–16.2	–	38.5–40.0	–
61 Denmark (modern badger ♂♀)		6.5–8.1	3.5–4.6	16.5–19.0	39.4–44.8	–	14.3–18.7
64 The Baltic States (modern badger ♂♀)		–	–	15.0–19.0	–	39.0–47.0	–

Table 71. **Badger.** Measurements of **Teeth:** P^4, max. length (L), M^1, max. breadth (B). Data in mm.

Locality	Age	P^4 L	P^4 B	M^1 L	M^1 B
1 Alvastra Eastern Trench	MN	9.4	7.6	15.4	12.5
2 Alvastra L. Hedell	MN	–	–	13.0	10.4
3 Alvastra J. Ekman	MN	7.7,	–	11.4,	–
		8.5,	–	12.6,	11.0
		9.4,	–	12.6,	–
		9.6	–	12.9,	–
				13.2,	–
				13.2,	–
				13.5,	–
				13.6,	–
				13.8,	–
				13.9	–
59 Korsnäs	MN	9.0	7.6	13.8	11.6
44 Segebro	MES	9.0	8.5	15.5	12.0
60 Denmark	MES	8.2–	7.5–	13.5–	11.5–
		9.2	8.6	15.5	12.7
61 Denmark		8.2–	7.1–	13.0–	11.7–
(modern badger)		9.9	8.8	16.0	13.9

7.1.11 Pine marten (Martes martes)

The pine marten thrives best in mixed forests but is also found in regions with coniferous forest. However, like the brown bear it is very adaptive to habitats and not tied to one biotope in particular and thus may also live in deciduous forests. As a result, the pine marten may range over vast areas looking for food. It is a carnivore which feeds mainly on red squirrel and other small mammals such as voles. It also eats birds, even as large as the capercaillie and is capable of killing large prey such as roe deer kids. Depending on the season it also feeds on birds' eggs, nestlings, insects and berries. Carrions are part of its food. The pine marten hides away and stores food for the winter. Primarily it is active at dusk and during the night, less often at daytime. Mostly the day is spent in hide-outs such as hollow trees, abandoned birds' nests or red squirrels' lairs. It is an agile animal which climbs very well and jumps most skilfully, but it seldom swims. In addition it is extraordinarily anti-social. Mating occurs from January to February. During spring the female gives birth to between two and five young (Lieberkind 1939a, p 275–276, van den Brink 1958, p 146–148, Siivonen 1976, p 116, Lepiksaar 1974, p 144).

The ecosystem of rich deciduous forest and also mixed forest within the neighbourhood of the pile dwelling and, further away, the woodland Holaveden would have been ideal biotopes for the pine marten. According to the results from the Eastern Trench the pine marten is the most common species among the

identified fur animals. Taking the results from earlier analyses into consideration the frequency of pine marten seems to be fairly high in some, lower in others (Table 31). However, remains of this species are not missing from any Alvastra bone samples, so the pine marten seems to be, together with the badger, the most common species among identified fur animals. This clearly indicates that the pine marten was trapped and brought back to the site regularly. Indeed, it seems to have been valuable prey to man in prehistory and was regularly hunted in Sweden since Mesolithic times (Larsson 1981, p 43, Lepiksaar 1974, p 149, 1982, p 118).

The red squirrel *(Sciuris vulgaris)* is considered to be the favourite prey of the pine marten. There are no remains of this species in the Eastern Trench material and there was in fact only one specimen identified in earlier analyses (Table 31). However, the red squirrel was probably present in the local environment, for this species seems to thrive well in forests containing large deciduous trees (Ekman & Iregren 1984, p 20). It is thus assumed that the lack of red squirrel remains in bone samples from the pile dwelling may rather depend on other reasons such as human selection or certain other factors (Section 2.2), rather than reflect a less favourable biotope. Besides man, natural enemies of the pine marten would have been the wild cat and large birds of prey, such as the golden eagle. These species were competitors for such prey as mammals and birds. It has been claimed (Lepiksaar 1982, p 118, 1983, p 143) that the competition presented by the wild cat would have been counter-balanced by the fact that the two species were not using the same ecological niche, since the pine marten, weighing less than 2 kg, stayed higher up in the trees chasing the red squirrel.

The body weight of a modern pine marten varies from 0.7 up to 1.8 kg, the body length from about 42 to 56 cm. The withers height is only about 15 cm (van den Brink 1958, p 146, Siivonen 1976, p 116).

Available measurements of teeth and jaws show variation in size among individuals represented in bone material from the site (Table 72). The differences may to a certain extent depend on sexual dimorphism. The dimensions seem to fall within the range recorded for both Danish and Baltic subfossil pine martens (Table 72). Measurement of teeth and mandibles of the Danish Mesolithic pine marten particularly indicate the presence of larger animals than found in the remains from the pile dwelling, while the same dimensions from Swedish, Danish and Baltic contemporary and sub-boreal localities seem to agree well with the measurements from Alvastra (Table 72). It has been argued that the subfossil Danish pine marten was larger in size than the modern species on the evidence of both tooth and long bone dimensions (Degerbøl 1933, p 534–544, 1943, p 183). One measurement (P_1–M_2, alveolar length) of the modern Swedish pine marten indicates the presence of really large individuals among the modern Swedish species (Table 72). It is, however, stressed that available measurements of material from the pile dwelling, as well as of recent Swedish material are in general far too few to make it possible to draw any conclusions regarding differences or changes in size between the subfossil and modern Swedish pine marten.

Probably prehistoric communities in the Alvastra region hunted the pine marten mainly for its valuable pelt. During the Middle Ages in Sweden skins of

pine marten were regarded as a source of fortune and were worth more than twice the skin of a red squirrel. In Finland the proportions in terms of value were 1:5, in Norway 1:6. Furthermore, in Norway a cow had the same value as two pine marten skins of good quality (Beckman 1954, p 250–252). It is probable that furs from animals such as the pine marten would have been considered an important part of barter or trade already by Middle Neolithic times. As for other fur animals identified in the material, the fur has its best quality during winter time. The snow makes them also easier to track. Hunting the pine marten by tracking down the animal on newly-fallen snow has a long history in Sweden (Ekman 1910, p 150–152, Brusewitz 1978, p 217, Arvidson 1983, p 117). The most profitable hunting season was probably from late autumn to spring, thus indicating human activity at the pile dwelling during the winter season.

One of the phalanges shows marks of being cut through (Table 77). The fragments show no marks of being gnawed by animals. Finds of intact long bones, scapulae and os coxae would indicate remains of bodies which had been skinned and then thrown away. Scavanging carnivores and birds would probably have been repelled by the pine marten bodies, since the anal glands produce an acrid smelling secretion (Lieberkind 1939a, p 274, Lepiksaar 1982, p 118). Skull and paws may have been left attached to skin and fur or they possibly constitute waste parts which had been cut off in the skinning process. There is no evidence of pathological changes in the remains.

Table 72. **Pine marten.** Measurements of **Teeth** and the **Mandible;** P^4 max. length (L), M^1 max. width (B), M_1 max. length (L), length of the cheektooth row, P_1–M_2, along the alveoli (AL) and height of the mandible behind M_1, on the buccal side (Hmbs). Alveolar dimensions (ad). Data in mm.

Locality	Age	P^4 L	M^1 B	M_1 L	P_1-M_2 AL	M_1 Hmbs
1 Alvastra Eastern Trench	MN	9.2, 9.6	–	9.1, 9.2, 9.6, 10.1, 10.7, 10.8	29.0, 29.0	8.7,
2 Alvastra L. Hedell	MN	8.6	9.0	9.8	24.8	8.5
3 Alvastra J. Ekman	MN	8.5	6.4, 7.5	9.2, 8.9, 10.5, 10.7, 11.0, 9.7 ad 10.0 ad 10.5 ad 10.6 ad	29.4, 30.0, 30.6, 30.7, 31.4, 32.0	8.0, 8.4, 9.0
40 Äs	MN	–	–	10.0	29.0	–
9 Ørum AA,	MN	–	–	10.0	–	9.6
Frennemark	MN			11.0 ad	31.2	8.8
65 The **Baltic States**	Sub-bor	–	–	9.2–11.2	–	8.2–10.5
12 Aamosen	MES-MN	8.4	–	10.0–12.0	29.5–33.6	9.3–12.0
60 Denmark	MES	8.1–9.5	8.5, 8.9	9.6–12.2	29.2–34.5	9.0–12.2
65 The **Baltic States**	MES	–	–	8.5–11.3	–	7.7–10.9
66 Sweden (modern pine marten ♂ ♀)		–	–	10.2, 10.4	32.2–39.7	–
61 Denmark (modern pine marten ♂ ♀)		7.5–9.5	7.7–8.8	9.2–10.9	28.0–33.0	9.0–11.0
67 Lithunia (modern pine marten ♂ ♀)		–	–	9.0–10.9	–	–

Table 73. **Pine marten.** Measurement of the **Radius;** max. distal width (Bd). Measurement of the **Pelvis:** length of the acetabulum on the rim (LAR). Measurements of the **Femur;** max. distal breadth (Bd) and max. breadth of facies patellaris (Fp). Measurement of the **Tibia;** max. distal breadth (Bd). Data in mm.

		Radius	Pelvis	Femur		Tibia
Locality	**Age**	**Bd**	**LAR**	**Bd**	**Fp**	**Bd**
1 Alvastra Eastern Trench	MN	8.9	10.2	14.8	7.0	10.1, 9.1 (burnt)*
40 Äs	MN	–	10.0	15.0	7.0	10.0
65 The **Baltic States**	Sub-bor	–	–	10.4–13.9	–	7.3 10.7
44 Segebro	MES	–	–	16.8	–	–
60 Denmark	MES	8.3–9.9	–	13.3–15.8	–	9.0–11.7
65 The **Baltic States**	MES	–	–	11.0–14.2	–	7.2–10.4
63 Lappmarken (modern pine marten)		–	–	13.0	–	9.1
61 Denmark (modern pine marten)		7.7–9.2	–	12.5–15.7	–	8.7–10.6

* According to von den Driesch (1976, p 3) on average 15 % of the size is lost.

Table 74. **Pine marten.** Measurements of the **Calcaneum;** max. length (GL) and max. breadth (GB). Measurements of **Metatarsals** (Mt I, Mt III, Mt IV, Mt V); max. length (GL) and max. distal breadth (Bd). Data in mm.

		Calcaneum	
Locality	**Age**	**GL**	**GB**
1 Alvastra Eastern Trench	MN	20.0	10.5

		Mt I		Mt III		Mt IV		MT V	
Locality	**Age**	**GL**	**BD**	**GL**	**Bd**	**GL**	**Bd**	**GL**	**Bd**
1 Alvastra Eastern Trench	MN	24.3, 25.4	3.2, 3.2	32.5	3.4	38.1	4.5	40.4	4.3

7.1.12 Lynx (Lynx lynx)

The lynx prefers a habitat of dense and wide forest and thrives in mountainous remote areas. The roe deer and hare are both considered to be the main prey. The lynx also feeds on small mammals, birds, foxes and larger prey, such as red deer. Observations on modern lynxes have shown that they seem to feed mainly on small prey animals such as rodents, fowl and hare from May to November and

larger prey and particularly roe deer in the winter. At times it may visit more inhabited regions where it can attack domestic animals, such as sheep. It is considered to be a ferocious animal which may kill more than it consumes. Primarily the lynx is active at twilight and at night. It mainly lies still during the daytime, preferring when possible a good view over the surroundings. As to social behaviour, the lynx is in general a solitary animal, wandering from one hunting place at another. During the mating season and until the young are born the male and female may remain together. Mating occurs in February to March/April time. The kittens, up to three, are born in May or June. The mother takes very good care of her progeny and they stay with her at least until the next mating season (Ekman 1910, p 120–122, Lieberkind 1939a, p 111–115, van den Brink 1958, p 156, Siivonen 1976, p 120, Werdelin 1981, p 68, Jonsson 1983, p 45–62, 69, 75–82, 105).

Neighbouring surroundings, as well as more distant regions within the resource area for Middle Neolithic man living in the vicinity of Alvastra pile dwelling may have provided good conditions for the survival of lynx. There were vast forest regions with fine access to dense shrubbery, caves and ledges which could be used as hide-outs and dens, and the supply of food animals was probably quite sufficient.

In view of the results from the Eastern Trench the remains of lynx are few. This is also mainly the case in earlier analyses (Table 31). Besides by man the lynx was probably only threatened by the wolf, which was a food competitor and held a high survival position in the ecosystem. There is a distinct animosity between the two species, which in general exists between felines and canids. In the case of the lynx it attacks the dog and treats the fox as a prey animal (Jonsson, pers.comm.). It has been pointed out that, if there is a chance, wolves may attack and kill a lynx. In environments where the wolf is frequent, populations of lynx seem to be less frequent or even absent. If, on the other hand, there are plenty of lynxes in an area, then the number of foxes seems to diminish (Lieberkind 1939a, p 115–116, Lepiksaar 1982, p 119). In this respect, however, it should be noted that the total number of identified fragments of the two species, wolf and lynx, does not differ much in the actual bone material from the pile dwelling. This may indicate that there was plenty of territory and prey to allow both species to co-exist within the resource area.

The northern lynx and the Swedish population in particular is the largest of recent lynxes. Lynx show no significant sexual dimorphism and the geographical variation is small (Werdelin 1981, p 39, 42). The modern lynx attains a withers height between 60 and 75 cm, a body length from 70 to 130 cm and a weight up to 40 kg (van den Brink 1958, p 151, Siivonen 1976, p 119). In Denmark the few measurable finds of subfossil lynx are seen to come from strikingly large animals (Degerbøl 1933, p 427–428).

Today the general hunting season is in the winter (Jonsson 1976, p 94). It is stressed (Jonsson, pers.comm.) that the lynx is a very difficult animal to hunt even during the winter when the snow makes tracking easier. Jonsson suggests (pers. comm.) that most hunting of this species during prehistoric times was probably

spasmodic and not systematic, at times taken place accidentally and incidentally in connection with the hunting of other game. The few lynx bone fragments from the pile dwelling do not contradict this opinion. It may thus be assumed that the hunting and killing of this highly vigilant animal demanded great effort on the part of Neolithic communities and like wolf hunting was probably associated with both status and prestige. The lynx thus provided prehistoric groups with probably valuable skin and fur, and this has been so ever since. At the beginning of the 17th century one fur of good quality from a lynx could be worth as much as 10–12 furs of beaver or 13–16 furs of brown bear or wolf (Ekman 1910, p 121). Like the other fur animals identified in the material, the winter pelt is best. The summer pelt is thin and of bad quality. The winter pelt is thick and extremely heat isolating and begins to grow even by October (Jonsson 1983, p 25).

Furthermore, lynx meat may well have been consumed (Section 6.2.5). It has been pointed out that the juvenile individual in the Eastern Trench material had probably been killed during the summer or in the fall when the young lynx *'träar'*, takes refuge in the trees, when it gets frightened and the mother is temporarily away (Jonsson, pers.comm.). Possibly the remains of a juvenile animal indicate food habits. In addition, with respect to the usefulness of the carcass, it has been reported that formerly, lynx fat was used therapeutically, especially in connection with rheumatism (Jonsson, pers.comm.). Such a use for the animal's fat was also discussed in relation to the badger (Section 7.1.10). Bone elements of lynx may also have been attractive in manufacturing bone objects (Table 76).

There are no distinct gnaw, cut or butchery marks on the fragments, and no evidence of pathological change.

7.1.13 Wild Cat (Felis silvestris)

The wild cat prefers a habitat of thick, large forests of varied composition but where there are also areas of open ground. Primarily it feeds on small rodents and birds but can also attack and consume larger prey, the size of hare and roe deer kids. Mainly it is a nocturnal animal which remains hidden during the day. The most active hunting occurs late in the evening and early in the morning. The den is often a hollow in a tree, a cave or a dense thicket. The wild cat jumps and climbs well but is a reluctant swimmer. Apart from the mating season in February two or more animals are seldom seen together. Hence the wild cat is a solitary animal. During the spring, in April, the kittens are born (Lieberkind 1939a, p 86, van den Brink 1958, p 151).

Mixed deciduous forest, with a rich supply of small rodents and birds, seems to have been its favourite habitat since Mesolithic times (Larsson 1978, p 189, Lepiksaar 1974, p 144, 1982, p 119). Forests and open grounds in the vicinity of the pile dwelling, as well as more distinct woodland such as Holaveden, must have provided ideal ecosystems for the wild cat. Considering the results from the Eastern Trench the remains of wild cat show a relatively high frequency among identified fur animals. Besides pine marten and badger it is the most common species. Referring to earlier analyses of bone material from the site, these show

similar results (Table 31). This indicates that wild cat was hunted and brought to the site fairly regularly. This also supports the view that biotopes were favourable to this species, giving the Alvastra people good access to it.

The wild cat was probably an important regulator of small mammals and birds (Lepiksaar 1982, p 119), and may at times have been a potential danger to young domestic animals in the neighbourhood, such as lambs. Besides man, natural enemies of the wild cat would have been wolf, lynx, red fox and large birds of prey, such as the golden eagle. The wild cat had a great advantage over the wolf and red fox in being able to climb up into trees. These species were also competitors for food. This was also the case with pine marten. The wild cat, however, in being extremely skilful in catching voles, was in this way superior to the pine marten (Lepiksaar 1982, p 119). Referring to the patterns of behaviour in mammals, it has been reported that carnivores within the same ecosystem avoid each other in accordance with an established ranking order (Lepiksaar 1983, p 143).

The modern wild cat has a weight of between 5 and 10 kg and a withers height of 35 to 40 cm and may attain a total length of about one meter (van den Brink 1958, p 151). The wild cat of northern Europe is thought to have undergone considerable reduction in size since the Pleistocene, and today the largest European wild cat lives in Spain (Kurtén 1959, p 205–215, 1965a, p 23, 1965b, p 20). On the metrical evidence it is clear that the subfossil remains of wild cat in Denmark show considerable variation in size and that even in the Mesolithic the population was comparable in size to the Pleistocene form i Europe, and thus also larger than the modern Spanish wild cat (Degerbøl 1933, p 401–422). Tooth and bone measurements from specimens excavated at the pile dwelling are very few. However, tooth measurements all fall below the upper limit and above the lower limit of Danish Mesolithic ones (Table 75).

In Sweden the wild cat seems to have been fairly regularly hunted by man since Atlantic times and at least into the Middle Neolithic (for example Lepiksaar 1974, p 149, 1982, p 119, Larsson 1981, p 43–45, 1983, p 39). There are no finds of wild cat in archaeological bone material dated to later time periods. As yet it has not been possible to ascertain when this species died out in Sweden. It has been argued that they probably became extinct at the end of the sub-boreal period (Lepiksaar 1983, p 137).

The wild cat was probably hunted mainly for its soft fur, but at least some of the long bones, including radius, ulna and tibia, were probably used in the manufacture of bone artefacts (Table 76). Possibly it was also used as food, but there is no clear evidence of this. The long bone fragments do not seem to have been broken open, unlike the ones noted in Mesolithic bone material (Lepiksaar 1982, p 119). In the province of Scania in southern Sweden remains of a juvenile wild cat have been found buried in a pit, and were covered with red ochre. The find is dated to the Atlantic period (Larsson 1984, p 82). This indicates that prehistoric communities may have hunted and caught wild cat for purposes and activities other than the usual economic ones.

None of the specimens show any distinct marks indicating that they were skinned or butchered. Neither are there distinct marks from gnawing and scoring

by mammal teeth. However, all specimens are fragmented except for some teeth, one scapula and a phalanx. Various taphonomic factors active during a long time have probably contributed to the fragmentation. Some bones may of course have been damaged in connection with skinning or other cultural activities. Others, such as the skull, tooth and paw specimens may have been left within furs. No pathological or other changes were noted.

Table 75. **Wild cat.** Measurements of P^4; max. length (L), max. breadth (B). Measurements of the **Radius:** max. proximal breadth (Bp) and max. proximal depth (Dp). Measurements of **Phalanx II** of Metatarsal III/IV; max. length (GL), max. proximal breadth (Bp), max. distal breadth (Bd) and min. breadth of the diaphysis (SD). Data in mm.

		P^4	P^4	Radius		Phalanx II			
Locality	**Age**	**L**	**B**	**Bp**	**Dp**	**GL**	**Bp**	**Bd**	**SD**
1 Alvastra Eastern Trench	MN	11.5 11.5	5.8 5.8	9.0	6.1	16.0	6.0	4.9	3.0
3 Alvastra J. Ekman	MN MN	10.9, 11.6	–	–	–	–	–	–	–
40 Äs	MN	11.5	5.8	–	–	–	–	–	–
12 Aamosen	MES-MN	11.5	–	10.2	–	–	–	–	–
48 Ageröd (Atlantic time)	MES	–	–	8.9	6.0	–	–	–	–
60 Denmark (Atlantic time)	Mes	10.7–12.1	5.2–6.3	9.5–10.5	–	–	–	–	–
68 MNH, Stockholm (coll. modern wild cat)		9.8j, 12.2	5.1j, 6.0	7.9j, 9.5	5.2j, 6.8	– 14.5	– 5.5	– 4.4	– 2.8
61 Denmark (coll. modern wild cat)		–	–	9.5, 10.1	–	–	–	–	–
69 Denmark (cat, *Felis catus*)		9.6, 11.5	–	7.5, 7.5, 8.3	–	–	–	–	–

7.1.14 Beaver (Castor fiber)

The beaver is adapted to a biotope of open forest where trees like oak, ash, birch and alder grow along slowly running watercourses, bog borders and lake shores and where the ground vegetation is luxuriant. Bark and buds from birch, willow and aspen make up the main food, but this species also feeds on herbs, sedges and rootstocks of water-lilies. Primarily the beaver is active from sunset and during the night. In undisturbed surroundings it may also be active during the daytime. It is a cautious and anti-social animal which swims and dives skilfully. It spends most of its time in the water. The den may be a cavity in the bank but can also be a more

complex construction of twigs and branches, 'a beaver cabin'. The entrance to the den is under the water. Within the habitat the beaver fells many trees. The water is held up by the building of dams although channels are constructed. This facilitates the movements of beaver and the floating and transportation of food supplies to the den. Like most non-hibernating rodents, the beaver stores up food for the winter. As regards its social behaviour, the beaver lives a settled life, alone in a den or as part of a small group. Such groups consist of members of the same family. They establish territories which they then defend against intruders. Mating occurs in February. The beaver is a strictly monogamous animal, so pairs tend to form for life. In general the young are born in May or June, but can be as late as the autumn. The female takes good care of her young whose number may vary from one to four and they may stay with her for more than a year (Lieberkind 1940a, p 427–433, 446–447, van den Brink 1958, p 89, Lavsund 1975, p 15–34, Siivonen 1976, p 91, Ekman & Iregren 1984, p 26).

Not too swiftly running watercourses, such as the Disevid stream, and possibly also parts of Tåkern may have offered during Middle Neolithic times swampy shores and banks with suitable vegetation for the survival of a beaver population.

Considering the results from the Eastern Trench, beaver remains are uncommon in the bone material. This also seems to be the case as judged by the earlier analyses of bone material from the site (Table 31). Besides man, the beaver has probably had many potential enemies. On land it moves rather slowly and clumsily and may have been threatened by brown bear, wolf, lynx, wild cat and possibly even pine marten and otter (Lieberkind 1940a, p 447). The big carnivores, such as wolf and lynx, were probably the most dangerous (Lavsund 1975, p 30). Remains of otter *(Lutra lutra)* have not been found in the material from the Eastern Trench, (Table 6) but was in some of the other samples (Table 31). It has been claimed that the presence of a beaver population and the dams it constructs would help to support waterfowl and fresh-water fish within the area (Lavsund 1975, p 35, Lepiksaar 1982, p 221). Furthermore, the creation of less wooded areas would encourage the survival of elk and hares and a range of small rodents (Lavsund 1975, p 35).

The modern beaver in Fennoscandia may attain a body length of more than one meter and a weight of about 12 kg up to more than 40 kg (van den Brink 1958, p 88, Siivonen 1976, p 90). It is a good meat producer and the meat from young animals is especially tasty (Lavsund 1975, p 42). The amount of meat from one beaver has been estimated to be between 5 and 15 kg (Larsson 1978, p 189). The beaver also provides a valuable pelt, warm and lasting. Also, both male and female produce a strongly smelling gland secretion called *bävergäll.* In times past this was much sought after and used against all kinds of illness and was thought to have a sedative effect (Lieberkind 1940a, p 446, Lavsund 1975, p 16). It has been argued that prehistoric peoples may have known and used *bävergäll* well back into antiquity (Lepiksaar 1982, p 121). Other parts of the body were also formerly used as medicine, such as the rump against labour pains (Ekman 1910, p 221).

Hence, in general, beavers were a profitable economic resource to prehistoric

communities. The relative low frequency of beaver remains in the bone material from this site may indicate that this species was not common locally and thus not easy to acquire. It may also indicate that beaver hunting was not especially widespread among these peoples or that they did not usually bring the bodies of beaver to the site for food preparation, skinning or other reasons. Possibly the incisors were attractive as sharp-edged tools (Table 76).

Like other fur animals, the quality of the beaver pelt is in general considered best during the winter. This is valid both for young and mature animals. The summer pelt is without doubt of inferior quality. Investigations of modern beaver have shown that, in Norway, the pelt seems to attain its highest quality from November to February (Valeur 1977, p 84–86, 95–96) and in Sweden from January to March (Lavsund 1975, p 45). The beaver has a valuable pelt, but Valeur (1977, p 96) considers it to be a most difficult animal to skin because of the fatty, though connective tissue which is attached to the skin and muscles. Moreover, Valeur emphasizes that the pelt may have many scars from bites, especially among the adult animals, and that such scars have lessened the value of the pelt. Valeur suggests (1977, p 85–86) that the best hunting time for the pelt is late autumn, before winter, and then from early spring into April, since the beaver in general seems to spend the winter in its den and seldom appears. He further stresses that bad weather and light, together with the snow, limit the hunting season in the winter. In Sweden beaver hunting at the time of the disappearance of the ice has a long history (Ekman 1910, p 214–215, Brusewitz 1978, p 206).

Taking meat value into consideration the beaver could well have been caught and killed during the summer and earlier in the autumn when it was probably at its fattest and the meat quality at its best. Consequently the remains of beaver might in fact indicate activities at the pile dwelling mainly from early spring to late autumn.

There are no marks from skinning or butchery on the skull fragment, neither are there any gnaw marks, pathological or other changes noted on the remains.

7.1.15 Mountain hare (Lepus timidus)

The mountain hare is adapted to a forest biotype to areas where the pasture is verdant, also to the borders of marshes and bogs and to the margins of streams and lakes where a shrub vegetation of aspen, willow, birch and rowen flourish. In the spring and summer the food mainly consists of herbs, leaves, buds and shrubs, while in the autumn berries are included. The main food during the winter is bark, twigs and also bilberry schrub and it seems to have a predilection for bark from aspen in particular. Like various other species at Alvastra, it is a good swimmer. Primarily it is active at night, and in the daytime often lies still in a hide-out, leaving quickly if disturbed. It prefers to live between rocks and stones. Although living a retiring life in forest-covered areas it is a creature of habit and often uses the same tracks when moving around (the so-called 'hare paths'). The female can

produce a litter of between two and eight young ones from one to four times per year (Liberkind 1940a, p 373–374, van den Brink 1958, p 76, Siivonen 1976, p 124, Ekman & Iregren 1984, p 27).

It seems likely that the environment in the general vicinity of the pile dwelling provided an amenable habitat for the mountain hare. In the bone material from the Eastern Trench few fragments were identified as mountain hare, and from earlier samples of site material, the finds vary from a total absence to about ten specimens (Table 31). The results indicate that the relative frequency of this species may be fairly low in the material as a whole.

Mountain hare has been an attractive prey for the lynx, wolf, wild cat and pine marten, as well as for some predatory birds living in the area. Its retiring lifestyle may have helped to protect it from man. Ekman & Iregren (1984, p 27) suggest that the way of life of the mountain hare probably meant that man was not such a dangerous enemy as other predators. On the other hand, its habit of creating 'hare paths' could have encouraged tracking and hunting.

The modern north European adult mountain hare weighs on average little more than 3 kg and attains a body length of about 50–60 cm (van den Brink 1958, p 76).

To the people who used the pile dwelling the mountain hare was a potential meat producer. The pelt may well have been used and probably also the long bones and even the metapodials were attractive as raw material for small bone artefacts (Table 76). Furthermore, hardly any other animal in Sweden seems to have played such an important part in ancient magic and folklore as the hare. It was often regarded as an animal which brought good luck, and was thus not killed. Formerly the Laplanders, for instance, did not hunt mountain hare for this reason (Ekman 1910, p 164, Brusewitz 1978, p 201). The few remains do not indicate that this species was regurlarly hunted and the bodies brought to the site. It has, however, already been stressed that bone sample size and distributions of the species may be modified by various factors (Sections 2.2 and 7.1.4) and render conclusions difficult. Among the mountain hare the winter pelt, which is white, has the best quality and is well developed from late autumn (Ekman 1910, p 159). The animal provides, however, a thin and fragile pelt which does not wear well and thus the fur may, as today among the Laplanders, have been mainly used for decoration (Lindlöf, pers. comm.). In Sweden in the Middle Ages the mountain hare seemed to have provided attractive furs. In the hunting legislation from Early Medieval times, it was counted as a pelt animal (Brusewitz 1978, p 201).

Today the hunting season of hare takes place, in the province of Östergötland as in most parts of Sweden, from September until the middle of February (Gyttorps Jakttabell 1/1 1983–31/12 1985). Since ancient times snow-track hunting of the hare has taken place in Sweden. Stalking in late autumn, before the snow had fallen and when the pelt had attained its fine quality, also has a long history (Ekman 1910, p 159, Brusewitz 1978, p 202). It has, though, been pointed out that mountain hare in general can be hunted the whole year and that it is more easily snared on snow-free ground and especially easy to snare from the time of the

melting of the snow into June, when it shows a great activity during the mating season (Lindlöf, pers. comm.). Without doubt the Alvastra people had taken advantage of such behaviour, and it can problably be argued that mountain hare was exploited through much of the year.

The few fragments of bone available do not show any clear marks from skinning or butchering. Neither are there any gnaw marks from mammal teeth on the bones or any evidence of pathology or other changes.

7.1.16 Ground vole (Arvicola terrestris)

The ground vole thrives in a biotope of dense vegetation at the borders of streams and lakes. It is a skilful swimmer and thrives also in fenland, among clumps of reeds and tufts of sedge, where it can construct platforms to live on. Using such habitats it feeds mainly on aquatic plats, such as sprouts of sedge and horsetail. This species, however, seems periodically to change biotope and thrives also in areas, sometimes far from water in arable and pasture land. Using such habitats it feeds on grass, seeds, roots of young trees and also hay and corn. Wherever it lives on land, it has the capacity to grub a large system of passages and 'store-rooms'. The 'store-rooms' may be dug down to frost-free depths. In winter it may hibernate but, if the weather is mild, it is active even during this season. It is a fertile animal, the female may have four litters per year with up to eight young ones in each (Lieberkind 1940a, p 481–487, van den Brink 1958, p 104, Siivonen 1976, p 97–98).

Environmental evidence suggest that the neighbourhood of the pile dwelling provided a biotope that would have been excellent for the ground vole. In the Eastern Trench remains of ground vole have been found down to the lowest strata of the excavated cultural layers, about 85 cm under the present ground level. Most of the remains come from a couple of adjacent squares and levels. This may indicate that the fragments, originally, come from whole bodies. A few remains of ground vole have also been identified in samples from earlier diggings at the pile dwelling (Table 31).

The ground vole most probably formed an important supply of food to predators such as pine marten, otter and marsh harrier present in the neighbourhood of the site. Remains of ground vole have often been identified in bone samples of Mesolithic and Neolithic date, coming from sites in woodlands and with access to water (Lepiksaar 1974, p 152, 1978, p 243, 1982, p 121, 1983, p 165, Aaris-Sørensen 1978, p 16). Usually the authors questioned whether the remains are contemporary with the human occupation of the site. Mostly the remains are considered as secondary residues of non-human origin, for example rests of pellets coming from birds of prey.

A ground vole may attain a body length of more than 20 cm and a maximum weight of 300 g and is the largest of the Swedish vole species (van den Brink 1958, p 104, Siivonen 1976, p 97). But if the ground vole is the largest vole species, it is

proportionally a small animal among the range of identified species from the site. Probably it had little food value to the people of the pile dwelling even if it is demonstrated that man has always eaten rodents (Clutton-Brock 1981, p 150–155). It is, however, quite possible that the remains of some ground voles are contemporary with the pile dwelling and not secondary residues.

On the fragments remaining there is no evidence of cutting or gnawing, and no pathology or other changes.

7.1.17 Field Vole (Microtis agrestis)

The field vole is adapted to various biotopes but has a predilection for moist ground, fields and meadows with tall grass, thickets, woodlands in the vicinity of watercourses, as well as for borders of arable land. In winter time, when if often lives in the forests in large numbers, it feeds especially on bark from young trees and bushes and may cause considerable damage. Dens and 'store-rooms' are often built above ground under cover of the vegetation. Well hidden passages are built above ground. The field vole also builds underground passages but they are rather superficial. It is a rather sociable animal which swims well, hardly climbs and adepts easily to a covering of snow. The field vole is an extremely fertile animal. One breeding pair may produce more than 300 offspring per year. The g round vole is today considered to be the most harmful vole in Sweden. There are, however, great fluctuations in population size (Lieberkind 1940a, p 487–491, van den Brink 1958, p 109, Siivonen 1976, p 99).

It seems likely that the field vole adapted well to the biotopes surrounding the pile dwelling. It was an important prey animal for carnivores and in the ecological system skilful vole hunters had not been lacking. Among others, the wild cat probably contributed most to the regulation of their numbers (Section 7.1.13).

In the Eastern Trench most remains of field vole emanate from cultural layers more than 50–70 cm under the present ground level. It can thus be argued that the remains of field vole may be contemporary with the pile dwelling and that they need not to be residues of a later secondary disturbance. In earlier analyses of bone material from the site there are no specimens of field vole identified (Table 31).

7.1.18 Common shrew (Sorex araneus)

The common shrew is not found restricted to one distinct biotope. It thrives in different kinds of territory such as open fields with tufty grass, swampy areas, forests and also in the neighbourhood of man. It has, however, a predilection for dampness and appreciates water in the vicinity (and is a good swimmer). Beetles, snails, earth-worms are its main food. It also feeds on dead bodies of mammals, together with corn in the autumn and seeds of coniferous trees in the winter. The small common shrew, with a body length of less than 9 cm and a maximum weight

of 16 g, is a very ferocious and voracious animal which attacks its prey with great frenzy. It may even attack mice. During one day it can eat more than half of its own weight. It is a solitary animal, lives in general alone and does not particularly like company. Both sexes have on each side of the body a gland which produces a strongly smelling secretion. The animals use the secretion during the mating period. The strongly smelling secretion has also another purpose, in that it deters carnivores. Certainly they may still bite the shrew to death but they do not consume it. On the other hand, owls and vipers are an exception and are fully prepared to consume the common shrew. The female has one to three litters per year. Each litter may contain three to ten young ones (Lieberkind 1940a, p 258–260, van den Brink 1958, p 34, Siivonen 1978, p 73–75).

It can be assumed that the conditions were good for the survival of this shrew in the ecological zone surrounding the pile welling. Common shrew remains are not found in the lowest cultural layers of the site. Nevertheless, it is possible that the specimen may still be contemporary with the pile dwelling. In earlier analyses of bone material from the site there are no fragments identified as common shrew (Table 31).

7.1.19 Enumeration of fragments manufactured to bone objects and fragments with butchery or gnaw marks

Table 76. Distribution of the number of fragments of different bone elements manufactured to **Bone artefacts** among species and one major taxonomic group.

Bone element	Species or group											Total
	Antler	Incisors	Canines	Ribs	Radii	Ulnae	Metacarpals	Tibiae	Fibulae	Metatarsals	Metapodials	n
Cattle	–	–	–	–	–	–	–	–	–	2	1	3
Elk	–	–	–	–	–	1	–	–	–	–	–	1
Red deer	1	1	–	–	–	2	–	–	–	–	1	5
Sheep	–	–	–	–	1	–	–	1	–	3	–	5
Sheep or goat	–	–	–	–	–	–	2	–	–	2	–	4
Roe deer	–	–	–	–	–	–	–	2	–	5	–	7
Small ruminants	–	–	–	–	–	–	2	–	–	–	2	4
Pig	–	2	5	2	–	–	1	–	5	–	2	17
Dog	–	1	–	–	–	–	–	–	–	–	–	1
Badger	–	–	–	–	–	–	–	1	–	–	–	1
Lynx	–	–	–	–	1	–	–	–	–	–	–	1
Wild cat	–	–	–	–	2	3	–	1	1	–	–	7
Mountain hare	–	–	–	–	1	1	–	1	–	1	–	4
Beaver	–	4	–	–	–	–	–	–	–	–	–	4
Total	1	8	5	2	5	7	5	6	6	13	6	64

Table 77. Distribution of the number of fragments (n) of different bone elements with **Cut marks** etc. among species and major taxonomic groups.

Bone element	Species or group								Total
	Cattle	Red deer	Big ruminants	Sheep	Small ruminants	Pig	Pine marten	Heron	n
Cranial Vault	–	–	–	–	–	1	–	–	1
Mandible	1	–	–	–	–	–	–	–	1
Atlas	–	–	–	1	–	–	–	–	1
Ribs	2	1	1	–	–	–	–	–	4
Furculum	–	–	–	–	–	–	–	1	1
Scapula	–	–	–	–	1	–	–	–	1
Metacarpals	1	1	–	–	–	–	–	–	2
Femur	–	–	1	–	–	–	–	–	1
Calcaneum	1	–	–	–	–	–	–	–	1
Metatarsals	3	1	–	–	–	1	–	–	5
Phalanges I	2	1	–	–	–	–	1	–	4
Total	10	4	2	1	1	2	1	1	22

Table 78. Distribution of the number of fragments (n) of different bone elements with **Gnaw marks** etc. among species and major taxonomic groups.

Bone element	Species or group							Total
	Cattle	Elk	Red deer	Big ruminants	Sheep	Small ruminants	Pig	n
Cranial Vault	–	–	–	1	–	–	1	2
Maxilla	–	–	–	1	–	–	–	1
Mandibles	1	–	–	–	1	1	–	4
Maxilla/Mandible	–	–	–	1	–	–	–	1
Cervical vertebrae	–	–	–	2	–	–	–	2
Lumbar Vertebra	–	–	–	–	–	–	1	1
Scapulae	4	–	–	–	–	–	1	5
Humeri	–	–	3	–	–	1	1	5
Radii	2	–	–	–	–	–	–	2
Ulnae	2	–	1	–	–	–	1	4
Radius+Ulna	–	1	–	–	–	–	1	2
Carpal bone	1	–	–	–	–	–	–	1
Metacarpals	1	–	–	–	–	–	2	3
Pelvis	3	–	–	–	–	–	–	3
Femora	1	1	–	–	–	–	1	3
Tibiae	1	–	3	1	1	–	–	6
Fibula	–	–	–	–	–	–	1	1
Tarsal bones	7	–	1	–	–	–	1	9
Metatarsals	3	–	1	1	–	1	3	9
Metapodials	2	–	–	1	–	–	2	5
Phalanges I–III	11	–	6	2	–	–	6	25
Total	40	2	11	8	2	2	18	93

7.1.20 Summary and comments

With regard to the relative frequency of identified mammals the results from the Eastern Trench seem, in many cases, to agree with those from earlier analyses of bone materials from the pile dwelling. Generally the remains of cattle dominate, followed by wild boar and pig (probably in an early stage of domestication). Also the remains of red deer have a relatively high frequency. Among the fur animals, badger and pine marten are the most common species although badger is the most frequent one in the bone material from the earlier excavations, while pine marten is the most frequent one in the bone material from the Eastern Trench. However, there are also distinct differences. The remains of roe deer consist for example only of a few bone specimens in the Eastern Trench, while this species seems in general to be better represented in the results from the earlier analyses.

In this connection I would like to emphasize that there are factors other than the

nature of the biotopes which may strongly have influenced the number of species and their relative frequency in the bone material. Heterogeneous distribution due to sample size and human selection are equally important factors, while another could well have been epidemic disease. Such factors may also have influenced the distribution of different parts of the skeleton and explain the lack of certain species in the bone material, such as the red fox and red squirrel.

Consequently, in view of the results given above, it can be argued that cattle-keeping has probably played a vital role in the life and economy of the Alvastra people in Middle Neolithic times. The same population may also have regularly hunted and killed various game and pelt animals, such as red deer, pine marten and badger. These animals, together with wild boar and early domestic pig, have constituted an important part of the economy. The bone specimens identified represent in many ways a human selection and may therefore reveal facts about social behaviour, as well as cultural and religious customs.

The mammal bone remains may also reflect seasonal activities at the pile dwelling and could perhaps be used to estimate the intensity of such activities. By means of the remains of juvenile wild boars/pigs, which have yielded a more precise age at death, seasonality has been considered (Section 7.1.5). Concerning the remains of deer, neither unshed antlers nor proximal parts of shed antlers have been found which could have assisted a seasonal evaluation of when the animals were killed or the antlers gathered. Furthermore, the determination of a precise age at death (that is with both a lower and an upper limit of the age given) has not been possible for the identified juvenile remains of red deer, elk or other game. Since 1938, all hunting in Sweden is strongly regulated and game management regulations have meant that old so-called peasant hunting has disappeared (Arvidson 1938, p 3–5). In the regions where the hunting of elk, red deer and roe deer is allowed, the hunting starts in southern and middle Sweden in general in October and may continue in November and for elk and roe deer until the middle of December or the end of the year. Concerning the wild boar the hunting lasts more of the year, with the exception of the months of March to September when sows with piglets are protected (Gyttorps Jakttidtabell 1/1 1983 – 31/12 1985). This long hunting period has been introduced to prevent, for the present, the wild boar to disperse over the country (von Essen, pers. comm.).

With regard to hunting larger game in the Middle Neolithic it is here assumed that usually, it has been hunted and killed when it was most accessible to man and in addition gave him the maximum yield of meat, optimum quality of fur etc. However, at times wild boar, deer and also badger may have been killed when damaging growing crops. Some big predators, such as brown bear and lynx, may also have been killed accidentally or by chance in connection with hunting other game. Arvidson (1975, p 115–116) points out that during peasant hunting, with the exception of wolf and wolverine *(Gulo gulo)*, the major part of big predator hunting has to be considered as accidental and not organised and that for example the brown bear was mainly killed by chance during the elk hunting.

In general it can be said that all meat producing animals put on weight during the summer season. With regard to deer they seem to be 20–30 % heavier in the fall

than in the late winter. Hence late summer and autumn can be considered as a most favourable time for hunting (von Essen, pers. comm.).

In the case of red deer it is especially easy to stalk during the fall when the stags, which used to range two or more together, return to their rutting places. These places can be the same year after year and in the rutting period the stags feed little and frequently display roaring and fighting behaviour. Except during the rutting period the hinds and calves also form groups spread in the region and segregated from the stags (von Essen, pers. comm.). Also the elk has its rutting period in late summer/early fall while for the roe deer it is in the middle of the summer. Stalking elk during the mating season has a long history in the Nordic countries (Brusewitz 1978, p 130). Among the peasant hunters, who continued a centuries old hunting culture, a great part of the hunting took place late in autumn (Arvidson 1983, p 129). Furthermore, taking into account the killing of males in autumn, it provided man with well developed antlers. Depending on the stag's age the red deer sheds the antlers from March to May (von Essen pers. comm.) and the elk sheds the antlers from December to February (Gardell 1958, p 141), while the roe deer sheds its antlers in November or December (von Essen 1958, p 592–599). In the case of roe deer it has not any special rutting places and it is likely that this animal was hard to come across and kill in the luxuriant summer greenery (von Essen, pers. comm.). Von Essen suggests that the most favourable time to track down, hunt and trap the roe deer probably was late autumn, especially in November and December if there was new-fallen snow in which the tracks were visible and easy to follow. Also, with respect to the meat quality, this period of the year was the best one. Moreover, in late summer and autumn, arable land with growing, ripe crops has constituted a great attraction to all deer varieties as well as to wild boar, thus exposing the animals more to human groups.

Yet another time of hunting has probably been the winter. Winter hunting on foot or on skis, with or without dogs, is ancient in Sweden, especially in the northern parts (Ekman 1910, p 40–44, Brusewitz 1978, p 130, Arvidson 1983, p 114). During the late winter, in March – April, depending on how cold the winter had been and how much it had been snowing, successful hunting on the hard crusty snow might well have taken place. There has to be a lot of snow to get a good crust which makes the surface hard enough to bear the hunter but not the game. Pregnant females had for example been especially vulnerable at this time (von Essen, pers. comm.). At this time of the year the animals had also probably been most exhausted or sick. In the case of elk, Arvidson (1983, p 115) stresses that it was often starved and underfed this season and hence the meat was of a poor quality.

Regarding the hunting of wild boar it has been suggested (von Essen, pers. comm.) that this hunting was not seasonally controlled. Von Essen reports that the wild boar is fairly easy to track down, especially when it has been snowing, and also to drive in a certain direction towards, for instance, a trap or hidden hunters, and it might very well have been hunted the whole year around.

For all game identified in the bone material from the Eastern Trench and judged as valuable to the people, an attempt has been made to suggest respectively the

best and least 'productive' hunting season(s), with respect to maximum human yield and accessibility of the game. The evaluations are based on the above mentioned facts and arguments and also on statements in the preceding Chapter 7. A summary of the suggested most likely hunting periods for the various game are shown in Fig.24.

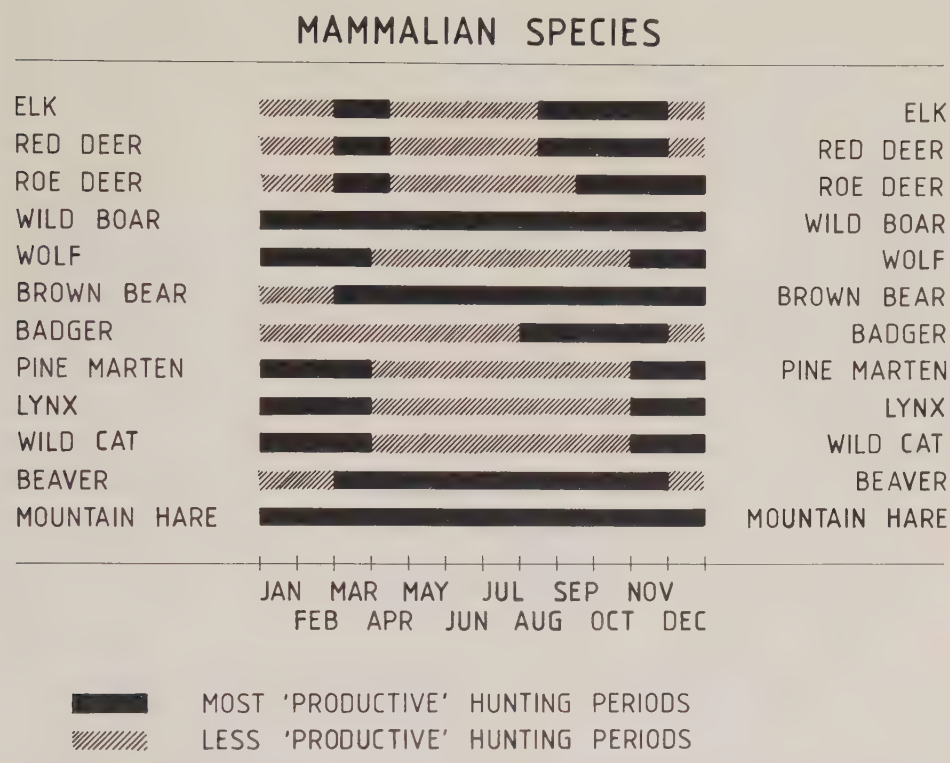

Fig. 24. Suggested HUNTING PERIODS for various MAMMALIAN GAME.

It is here argued that late summer and autumn have been ideal periods for the hunting of most species regardless of their eventual occurrence and frequency in the bone material. For species well represented in all bone samples referred to here and which are regarded as mainly meat, fat or fur producing animals such as wild boar, red deer, badger and pine marten the fall is considered to have been a 'productive' season. For some, such as wild boar and mountain hare, the hunting and trapping may have taken place in all seasons and for all valuable fur animals, with a possible exception of brown bear and beaver, the winter was an important season.

In the case of domestic livestock, it is argued that slaughtering in general took place in late autumn with regard to both weight, storing and conserving. It is however emphasized that animals might have been slaughtered at any time of the year for other reasons, especially cultural ones. In this connection it may be noted that deer meat, when stored, runs far less risk of becoming rancid than cattle meat

(Arvidson 1978, p 146). This depends on the fact that the deer, during an increase in weight, develop so-called depot fat. The depot fat is deposited mainly around the kidneys and also under the skin, while cattle have both intermuscular and intramuscular fat deposited. During meat preserving, the depot fat can be removed, which helps to protect against rancid changes (Arvidson 1978, p 146).

As a result of 1) the preceding study of juvenile pig remains which suggested that the most active period in the use of the pile dwelling was from March to October, 2) the best season to slaughter and 3) the most 'productive' hunting periods, it can be argued that the mammal remains indicate considerable activity on the site from early spring to late autumn, possibly with a peek in the autumn. The remains of fur animals such as pine marten also indicate activities in the winter season.

Besides the mammals identified in the bone material from the Eastern Trench remains of otter, red squirrel and hedgehog (Erinaceus europaeus) have been identified in bone samples from earlier excavations at the site (Table 31). Both otter and red squirrel could have been valuable fur animals and thus hunted in the winter by following their snow tracks. The pelt has in general a good quality from late autumn and hunting offered to be fruitful from the beginning of November until May. Formerly the otter seemed also to have been hunted during the mating season, which as a rule occurs in February (Ekman 1910, p 145–147, 153–156, Lieberkind 1939a, p 306, Brusewitz 1978, p 204–205, 216). Besides providing man with valuable furs the bones of otter might have been used therapeutically, for instance as an antipyretic (Brusewitz 1978, p 216, 241). Some sources also maintain that, in Sweden, the otter in times past was caught alive and then tamed and trained to bring back fish to its master (Lieberkind 1939a, p 311, Brusewitz 1978, p 216, 241–242). With regard to the red squirrel the meat seems to have been a popular element in catering during the Middle Ages in Europe (Brusewitz 1978, p 204). Formerly the meat was also commonly eaten in Sweden (Ekman 1910, p 157). Hence it is reasonable to assume that it was also consumed in prehistoric times. The hedgehog might have been killed and taken to the pile dwelling to be cooked. Meat of hedgehog has been eaten in historic times (Lepiksaar 1982, p 121). This species usually spends the time from October to May hibernating (Siivonen 1976, p 73). Remains of this animal thus emphasize activities in the pile dwelling in the warmer period, from late spring to early autumn. Hence the finds of otter, red squirrel and hedgehog fit well into the picture of activities in the pile dwelling.

The two formulae (Sjøvold, 1986 and Matolsci, 1970/71), which have been used to calculate the withers height for cattle (Section 7.1.1, Tables 47 and 48) give different results. Concerning the metacarpals and metatarsals from cattle, Sjøvold's formulae gives a faster increase of the withers height as a function of the maximum bone length (GL) than does Matolsci's formulae. As the withers heights given by Sjøvold's formulae are smaller for short bone lengths the two sets of curves (Sjøvold's and Matolsci's) will intersect. The crossing points are:

	♀	♂
Metacarpals (GL)	21.9 cm	22.0 cm
Metatarsals (GL)	26.3 cm	25.1 cm

Furthermore, within the actual range of interest, Sjøvold's formulae give intersection curves as to sex with regard to the metacarpals. The crossing point is at 20.2 cm (mc, GL). Accordingly bulls get a smaller withers height than cows below that point and a bigger withers height above the point. A comparison of the two formulae is shown in Fig.25.

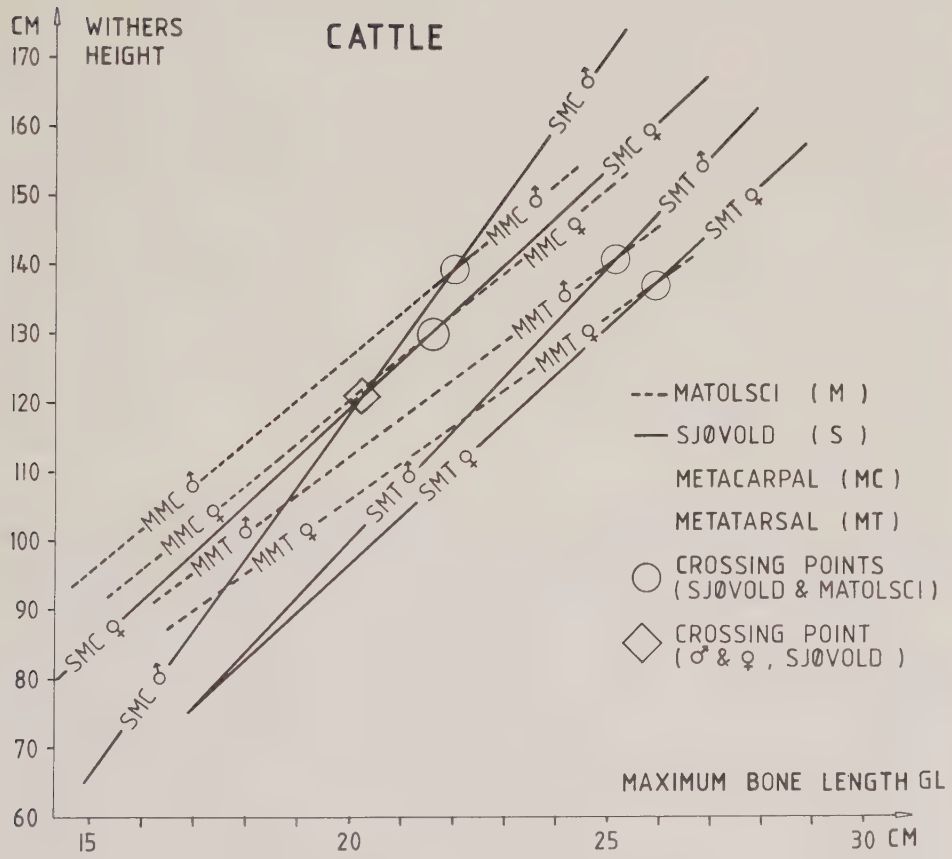

Fig. 25. CATTLE. WITHERS HEIGHT as a function of metacarpals (GL) and metatarsals (GL) according to Matolsci's (1970/71) and Sjøvold's (1986) formulae.

The two formulae (Teichert 1969, Sjøvold 1986), which have been used to calculate the withers height for wild boar and domestic pig (Section 7.1.5 and Table 66), also give different results. Sjøvold's formulae give bigger withers heights below an ulna (GL) of 23.3 cm, a talus (GL1) of 4.67 cm, a metatarsal III (GL) of 12.4 cm and a metatarsal IV (GL) of 11.5 cm and smaller withers heights above these values. In the case of the talus a comparison of the two formulae is shown in Fig.26.

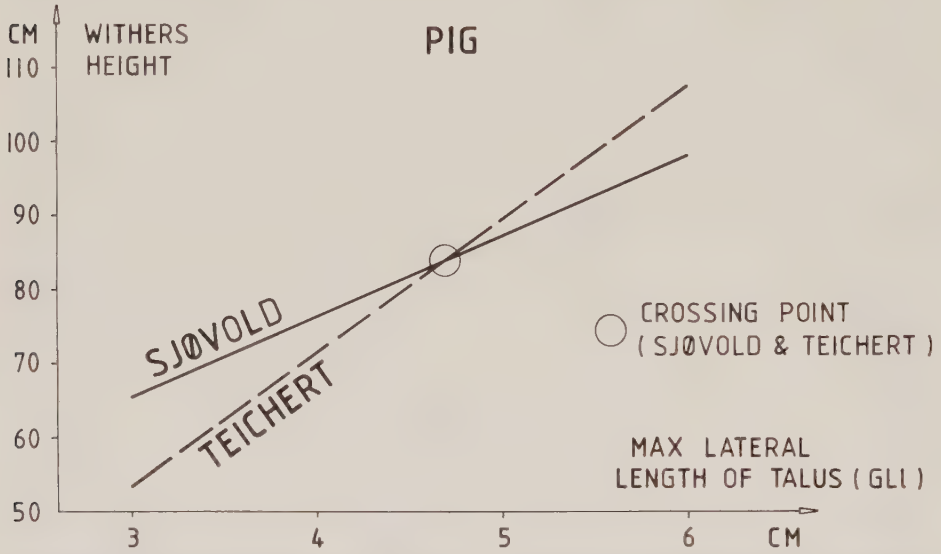

Fig. 26. PIG. WITHERS HEIGHT as a function of talus (GLl) according to Teichert's (1969) and Sjøvold's (1986) formulae.

7.2 Birds

The few remains of bird bones, 0.4 % by number and 0.04 % by weight, in the identified bone material from the Eastern Trench represent proportionally, a great variety of species (Table 6). In the earlier analyses of bone material from excavations at the site the finds of bird bones are in general very few, possibly with the exception of teal. As is the case of material from the Eastern Trench, they represent many different species (Table 79). Fowling provided both a contribution and variation to the meat diet, as well as raw material for bone artefacts and ornaments. During the spring and early summer months the gathering of birds eggs provided a further food resource. Only one bone specimen, a furculum from a heron, shows a couple of cut marks (Table 77 in Section 7.1.19). There are no gnaw marks or pathological changes on the bone fragments.

7.2.1 Crane (Grus grus)

The crane is a migrant, which breeds sparsely in swampy and peat bog areas. Nowadays it thrives best in woodlands with coniferous forest, for example in Holaveden, but can be found from southern to northern Sweden. The migration flights arrive in southern Sweden during March–April time and leave these parts

Table 79. Number of fragments (n) of **Birds** occurring in bone material from the excavations of the pile dwelling in 1909–1911, 1912, 1913 and 1919, earlier analysed by A. Pira (1910), L. Hedell (unpublished bone lists) and J. Ekman (1977, unpublished bone list.

	Pira	Hedell					Ekman	
	1909	1910	1911	1912	1913	1919		**Total**
Species	n	n	n	n	n	n	n	n
Golden eagle (Aquila chrysaetos)	–	–	–	3	–	–	1	4
Honey buzzard (Pernis apivorus)	–	–	–	–	–	–	1	1
Marsh harrier (Circus aeruginosus)	–	–	–	1	–	–	–	1
Tawny owl (Strix aluco)	–	–	–	–	2	–	1	3
Capercaillie (Tetrao urogallus)	–	1	–	–	–	1	1	3
Woodcock (Scopolax rusticola)	–	–	–	–	–	–	1	1
Mallard (Anas platyrhynchos)	–	–	1	–	–	–	1	2
Pintail (Anas acuta)	–	–	–	–	–	2	–	2
Teal (Anas crecca)	–	–	9	–	–	–	13	22
Wild goose sp (Anserinae sp)	–	1	–	–	–	–	–	1
Whooper swan (Cygnus cygnus)	–	–	–	–	–	–	1	1
Swan (Cygninae sp)	–	–	–	–	–	1	–	1
Total	–	2	10	4	2	4	20	42

of the country in September to October. Its food is mainly vegetable but the crane may also feed on insects, worms, small mammals, frogs and fish. Animal prey may predominate at times during summer. Since it is a fairly good swimmer it is not afraid of wading out in rather deep water. The crane is a very cautious and vigilant bird so it is hard to get close and it builds its nest in the most remote parts of the habitat. It is a sociable bird which thrives in flocks. During the spring it performs its wellknown mating dance. In general the crane is considered to be an intelligent bird which can adapt its way of living to available conditions. Kept in captivity it often becomes more omnivorous (Lieberkind 1937b, p 316–321, Bruun & Singer 1975, p 102, Cramp & Simmons 1980, p 618–626). It has been suggested (Stolpe & Arne 1912, p 20) that the crane was kept as a domesticated watch-bird during the Vendel period in Sweden. A possible explanation of this may be its high, penetrating trumpet-like call. In some parts of the East it is regarded as a holy bird and treated with special respect (Lieberkind 1937b, p 317).

It is quite possible that the crane might have found the biotope in the vicinity of the pile dwelling suitable for breeding during Middle Neolithic times. Today it is mainly found in coniferous areas where it is not disturbed by people. Possibly its preferences were not the same in prehistoric time when unspoiled countryside was more common. At times it might have been hunted while passing the region during migration flights. These always take place in daytime. It is true that the crane in general flies very high but the flock, often large, may descend to take a rest on a meadow or bank (Lieberkind 1937b, p 318, Cramp & Simmons 1980, p 619, 621–622). Besides man and the golden eagle (Lepiksaar 1983, p 147) this large, heavy and extremely vigilant bird does not seem to have had any potential enemies in the area.

The crane may attain a total length of 115–120 cm and has a wing span from 200 up to 230 cm. The weight is between 4 and 6 kg (Bruun & Singer 1975, p 102). In Western Europe, during the Middle Ages, the crane was highly regarded, the meat being considered a delicacy (Brusewitz 1978, p 165). The people who used the pile dwelling might well have considered the crane a useful meat source and perhaps also killed it for its ornamental plumes (the innermost wing-quills).

Remains of crane have not been identified in earlier analyses of bone material from the pile dwelling and referred to here (Table 79). Finds of this migratory and possibly breeding bird in the bone material may emphasize a use of the site from spring to autumn.

7.2.2 Heron (Ardea cinerea)

The heron belongs to the stork birds *(Ciconiiformes).* In Sweden today it is found in the southern part of the country. This limit coincides with the northern spread for this species in Europe. Usually it is a breeding, partly migratory bird which may be found in wintertime, but this is not common. The migration flights arrive as early as February–March time from the south and usually at night. The heron thrives in eutrophic environments, that is, at nutricious lakes, streams and also seas with luxuriant vegetation on shores and banks. This bird may also be active at night. The question of its main food has been varyingly discussed. Some are of the opinion that it mainly feeds on fish such as roach, eel and cod, while others maintain, by studying pellets and the ground under the nests, that its main food is of various kinds and may consist both of fish, fish fry, water insects, snails, shrimps and also mice and nestlings. Normally the heron breeds in pairs, living in colonies. The nests are built high up in trees usually standing near the water. Old nests are enlarged and used again year after year (Lieberkind 1940b, p 284–295, Bruun & Singer 1975, p 34, 38).

Within the ecological system surrounding the pile dwelling in Middle Neolithic times, the heron ought to have been able to thrive well. The region provided large moist areas rich in food and places for breeding. Probably, however, it did not in general pass the winter in the area. The sub-boreal climate might have offered warm summers but in contrast rather cold winters. It is, however, stressed that

cold weather per se is not the main problem for the heron. The crucial point is the water, since this bird needs to have access to open waters to be able to feed.

The heron is a large bird. It may attain a total length of up to one meter and has a wing span of about 140 cm. Like the crane the heron was in medieval times regarded as a tasty bird whose meat tasted like roe deer meat. It was above all the young birds which were desirable (Brusewitz 1978, p 163). Probably the heron was not simply hunted for meat in prehistory. It has magnificient plumage, and this may, as in recent times, have been attractive to Middle Neolithic peoples.

Remains of heron have not been found in the bone material from earlier excavations at the pile dwelling (Table 79). Being probably a migrant breeding species rather than a wintering one, the furculum of the heron may represent a heron killed between early spring and late autumn.

7.2.3 Capercaillie (Tetrao urogallus)

The capercaillie belongs to the family of forest fowls *(Tetraonidae)* and is the largest of gallinaceous birds *(Galliformes)* in Sweden or any part of Europe. It is a resident breeding bird which today may be found all over the country, although in the most southern parts only during the winter. It lives in various forests but prefers coniferous trees. It may also thrive in a mixed young forest with elements of oak, birch, aspen and alder, especially if there is a good ground vegetation. It also likes to have access to more open moist ground. In spring, summer and autumn it mainly feeds on the ground, on buds from surrounding trees, berries, acorns and seeds. The winter fodder, primarily taken i crowns of trees, is mainly pine-needles. The chickens, however, eat insects, larvae and worms and then gradually change over to vegetation. The capercaillie moves easily in the trees but prefers to stay on the ground. Like all gallinaceous birds it is not a skilful flyer but a fine runner. In general the nest is a simpel hollow in the ground under a bush. The capercaillie is a polygamous bird. Most of the year the cocks are solitary but during the mating season in spring cocks and hens gather in special mating grounds. The capercaillie courtship is with predilection located to grounds with fairly thin or young forest, at forest borders near fen areas or in thin wooded peat-bogs. The courtship starts in March–April time and lasts about a month. The cocks begin to 'play' from a branch in the trees but then proceed on the ground (Lieberkind 1937b, p 153–159, Bruun & Singer 1975, p 94, 96, Cramp & Simmons 1980, p 433–443).

According to the vegetational history of the area around the pile dwelling (Göransson 1982b, p 111–116, 1986) the mixed deciduous forest of oak, elm and lime dominated the wooded area surrounding the pile dwelling in the Middle Neolithic. Groves of pine and birch probably also existed on more dry soils in the vicinity, as for instance in the area of Isberga and Omberg. Moreover, there were planty of moist areas. Further away, in Holaveden, coniferous woods probably also grew. Thus conditions favourable to the capercaillie were not lacking in the region. Furthermore, it has been pointed out that, in Denmark, many finds of capercaillie were noted in bone material from 'Ertebølle' settlements of Atlantic date. This means that the capercaillie had the ability to adjust to biotope of mixed

deciduous forests (Winge 1903, Aaris-Sørensen 1978, p 14–15).

Besides man there were many predators in the ecological system contributing to the regulation of this species. For the wolf, the lynx, the wildcat and also for the large birds of prey the capercaillie was probably a desirable prey. Being often on the ground it was easily accessible. During courship the cocks were especially vulnerable (Ekman & Iregren 1984, p 28). The nest, eggs and nestlings have also been easy to get at.

There exists a pronounced sexual dimorphism in size between cock and hen. The cock may attain a total length of up to one meter and a weight of 4 to 5 kg. The hen attains a total length of about 60–65 cm and a weight of about 2 kg (Lieberkind 1937b, p 154, Bruun & Singer 1975, p 96).

Probably the capercaillie has been particularly killed by human groups for meat. In bone samples from the earlier excavations at the site a few pieces of capercaillie have been identified (Table 79).

7.2.4 Teal (Anas crecca)

The teal is the smallest species of the family of swimming ducks *(Anatinae)* and is a most skilful flyer. It is a migrant, nowadays breeding all over Sweden. In the southern part of the country the teal may pass the winter there if the conditions are extremely good. This, however, occurs very seldom. It thrives on small lakes both in wooded and open areas where it seeks out tufts of sedge and osier. It may also be found in pools, tarns and even in small streams. The food is to a great deal vegetarian and consists of aquatic plants etc. The teal also requires animal food. Like other wild ducks the teal is monogamous. In general the female duck lays a great number of eggs. The nest is prepared on a tuft or under scrub, fairly freely, well away from water (Lieberkind 1940b, p 174, 182, Bruun & Singer 1975, p 52, 54, Cramp & Simmons 1977, p 494–504).

It can be assumed that during Middle Neolithic times the ecological conditions in the vicinity of the pile dwelling ought to have been favourable to the teal's survival. This small duck has a total length of at least 35 but less than 40 cm and a wing span of about 60 cm (Brehm & Lieberkind 1940b, p 182, Bruun & Singer 1975, p 54). It provided tasty meat and was probably an attractive bag for man especially during the migration season since then the teal, as well as other wild duck species, gather in great flocks. For predators in the area, such as the marsh harrier (Table 79), the teal was also a desirable prey.

Remains of teal have been identified in bone material from the earlier excavations at the site. Considering the total number of bird fragments which has been identified in the bone material referred to in this context, 57 pieces, about 40 %, come from teal. The teal is in fact the only bird represented by more than 3 specimens. The presence of teal remains in the samples also indicates the use of the pile dwelling from spring to autumn.

7.2.5 Wood pigeon (Columba palumbus)

The wood pigeon is a migratory bird which nowadays breeds in great numbers in the south, middle and also large parts of northern Sweden. Originally it was considered a shy, reserved bird preferring wooded regions in the vicinity of water and also agricultured areas. Its food consists mainly of vegetation, for example seeds, berries and acorns. The pigeon gets its food on the ground. Lately its way of life seems to have changed to a certain extent. Some of its shyness has disappeared and today it is found in cities, gardens and parks. The number of wood pigeons has also increased and so has the competition for food. The main reason for this is probably the great reduction, at times extinction, of important birds of prey. Usually the wood pigeon arrives in Sweden in early spring, March–April time, and may stay until October. It may stay longer and at times pass the winter in the southern parts of Sweden, if the weather is mild and the supply of for instance acorns is good. The nest is rather carelessly made of twigs in a tree fork. During the summer the female can hatch eggs on four separate occasions, with only two nestlings being produced each time. Apart from the breeding seasons wood pigeon gather at times in big flocks (Lieberkind 1937b, p 238, 254–255, Bruun & Singer 1975, p 166).

The spring and summer conditions within the ecological system surrounding the pile dwelling would have been favourable for the wood pigeon. There were forest regions with open grounds, arable land and watercourses. Probably it did not in general winter in the area. The pigeons could well have been regulated by smaller mammalian predators but above all by birds of prey. These and not man have been considered to be the wood pigeon's worst enemies up until recent time (Lieberkind 1937b, p 254).

There are in fact two species of pigeon *(Columbidae family)* which are found in Sweden, the wood pigeon and the stock dove *(Columba oenas)*. The wood pigeon is the largest and may attain a total length of 40 cm (Bruun & Singer 1975, p 166). It is probable that the wood pigeon has supplied prehistoric man with seasonally regular meat and also valuable feathers. The wings have especially attractive ornamental feathers (Lieberkind 1937b, p 240).

In bone materials coming from the earlier excavations at the pile dwelling neither of the two species have been identified (Table 79).

7.2.6 Meadow pipit (Anthus pratensis)

The meadow pipit belongs to the passerine order *(Passeriformes)*. This group of birds is the most common one in Europe both considering numbers of species and numbers of individuals. In Sweden the meadow pipit is a breeding migrant, frequent practically all over the country. It arrives in March–April time and moves away in September to October. In the most southern part of the country small flocks can also be found wintering. It is not tied to one biotope but has a predilection to breed on shore meadows, bogs and in the north on mountain moors. During the migration flights the birds often rest on fields, meadows, arable

and pasture land. It is an insectivore which looks for food mainly on the ground (Lieberkind 1938, p 428, Bruun & Singer 1975, p 192, 204).

The meadow pipit had, during Middle Neolithic times, a good opportunity to breed and thrive within the ecological system of the pile dwelling area. The meadow pipit is to be classed within the range of small birds and has a total length of between 14.5 and 16 cm (Lieberkind 1938, p 428, Bruun & Singer 1975, p 204). It is possible that this species was caught and eaten by man, as an 'edible small bird'. It may also have landed up in the Alvastra cultural layers by accident. Remains of meadow pipit have not been found in other previously analysed bone material from the site (Table 79).

7.2.7 Tree pipit (Anthus trivialis)

The tree pipit is one of the most common birds in Sweden nowadays. It is a breeding migrant and is found all over the country but usually it does not cross the upper limit of the coniferous forests. This species thrives best in thin forests, glades and more open country of trees and bushes. It is an insect eater and often hunts the food in the trees moving about on the upper branches. It may also easily move on the ground where it, like the meadow pipit, builds its nest in the shelter of a tuft of vegetation or in a hollow (Lieberkind 1938, p 432, Bruun & Singer 1975, p 192, 202).

For this pipit species also the conditions would have been favourable in the vicinity of the pile dwelling. Like the meadow pipit it is a small bird and attains a total size of only about 15 cm (Bruun & Singer 1975, p 202). Possibly it too was considered a potentially 'edible small bird'. No remains of tree pipit have been found in other previously analysed bone material from the site (Table 79).

If the remains of the migratory tree pipit and meadow pipit have been brought to the pile dwelling through human activities, it would again indicate use of the site during the migration time, that is, between spring and autumn.

7.2.8 Summary and comments

The bird bones identified in both the bone material from the Eastern Trench and in the analyses from the earlier excavations at the pile dwelling indicate that remains of birds are few in the total bone material. In turn this may signify that the Alvastra people did not consume much bird meat, at least not at the site. It is possible that bird hunting was in general of minor importance in their life and economy. The situation may of course be distorted by a loss of fragments due to taphonomic processes. Bird bones in particular are relatively smaller and lighter and might easily have been chewed and broken into pieces by both man and other animals (taken away by dogs, other scavenging mammals or even by birds). Such differential selection among bone remains has already been stressed (for example Lepiksaar 1982, p 105).

Although the remains are few, they show a great diversity among species. Apart from the seven species identified in the bone material from the Eastern Trench there are about ten other species identified in the other samples from the site

(Table 8). Among the seven species from the Eastern Trench there are only two, capercaillie and teal, which have been previously identified. Obviously there was a considerable variety of birds existing in the area, providing a food choice for the Alvastra people, at least from spring to autumn, which was probably greater than that of mammals or fishes. This access to various different species might imply that man got in general a random sample of species when out catching birds, and consequently he had not always brought back the same species. On the other hand it can be argued that an abundant bird fauna has provided the opportunity to be more selective and choose special birds for special purposes both from a nutritional, utilitarian and ornamental point of view, and the remains may well reflect such a choice. From this point of view, eight specimens, about 73 %, of the identified bird remains from the Eastern Trench come from more meaty parts of the bird carcass and the remaining three from less meaty skeletal areas (Table 19 and Section 6.3). Among these specimens four come from the wings where, for instance, ornamental feathers are to be found.

As established in Sections 7.2.1 – 7.2.7 breeding migrants dominate the identified species. Six species are migratory birds. It is likely that all of them also have been able to breed in the Alvastra area. Among these the heron, wood pigeon and meadow pipit may today pass the winter in the southern part of Sweden if the conditions are favourable; exceptionally also the teal. Considering the sub-boreal climate in Middle Neolithic times, it is not especially likely that over-wintering has taken place among these species. The two remaining species, the crane and the tree pipit, migrated both before the winter. There is only one species, which is resident, the capercaillie identified in the material. Hence the proportion of migrants to residents in the Eastern Trench material is 6:1. The proportion of migrants to residents which have been identified in earlier analyses of bone material from the site (Table 79) is very much the same, 8:2. Among the latter migrants three, that is, the golden eagle, whooper swan and mallard might have been wintering. The woodcock and pintail were unlikely to be winter residents. The honey buzzard, marsh harrier and geese migrated before the winter. It should be noted that the wild goose specimen comes from either the greylag *(Anser anser)* or bean goose *(Anser fabialis)*. The tawny owl was (like the capercaillie) a resident. Possibly both the golden eagle and pintail were breeding in the area (Bruun & Singer 1975, Cramp & Simmons 1977, 1980, 1983). The proportion 6:1 and 8:2 of migrants to residents may thus point to a more intensive use of the site from spring to autumn rather than during the winter. It is, however, stressed that the best time in general to catch birds, especially nestlings, and also to gather eggs is during the breeding season between spring and early summer. In certain areas some species, for instance cranes and wild geese, are easy to get hold of during their migration flights (Enqvist, pers. comm.).

7.3 Fish

In spite of their small weight the fish bones represent about 10 % of the fragments among the identified material. In comparison, the remains of fish may be

considered from the huge bone sample (2.5 metric tons) from the Eketorp ring-fort on Öland, Sweden (400–1300 A.D.). The fish bones amounted to about 74,000 fragments but their weight was only 2.8 kg (Hallström 1979, p 422), hence about 0.1 % of the total weight of 2.5 metric tons of bone. In comparison, the bone material from the Eastern Trench has a total weight of less than 42 kg. The fish bones represent 76.7 g (0.2 % of the weight), hence the doubled percentage compared to the Eketorp remains.

It seems likely that fish, constituting a major protein resource, has probably provided the Alvastra Neolithic people with an important component of their diet. In contrast to the fish remains from the Eastern Trench, the other fish bone samples are in general few and the number of species not so variable in the earlier analyses (Table 80). One explanation at hand is that the former excavation

Table 80. Number of fragments (n) of **Fish** occurring in bone material from the excavations of the pile dwelling in 1909–1911, 1912, 1913 and 1919, earlier analysed by L. Hedell (1910, and unpublished bone lists) and J. Ekman (1977, unpublished bone list).

	Hedell						Ekman	
	1909	1910	1911	1912	1913	1919		**Total**
Species	n	n	n	n	n	n	n	n
Pike	a few	8	25	5	1	30	6	>75
Perch	–	–	5	–	–	2	–	7
Wels	–	–	3	2	1	2	8	16
Bream	–	1	–	–	–	–	1	2
Silver bream	–	1	–	–	–	–	–	1
Total	a few	10	33	7	2	34	15	>101

techniques did not for example include water-sieving. Generally the fish bones are small, light, often fragmented and may easily escape the attention of the excavator and thus be overlocked, especially without water-sieving (Clason & Prummel 1977, p 173–175), even if the circumstances for preservation are to be considered as favourable. In the case of the Eastern Trench sample such a source of error has been diminished, since all excavated material was water-sieved and in addition sediment and soil samples were taken.

7.3.1 Pike (Esox lucius)

The pike is an environmentally tolerant fish that thrives well in both fresh and brackish water. Today it is found all over Sweden preferring shore regions of lakes, larger rills and streams rich in vegetation but where the water is flowing slowly, that is, in the so-called 'bream region'. During the winter it moves off from the shore areas out to deeper water. The pike is a predatory fish constituting the last link in a lake-nutritional chain. From the beginning of its life it feeds on zooplankton but changes very soon to fry of roach, rudd, bream and other species. After the first years its food consists almost exclusively of fish, even of other pike.

Hence, from its first to its last years the pike can be a cannibal. When available it also eats frogs, mice and at times duck nestlings. It is not a shoal fish, rather a solitary species living in a sedentary way within one and the same area. Remaining motionless in the vegetation it lies in wait for its prey and then attacks very fast. The spawning season extends during a proportionally long time, from the beginning of the clearing of ice in March until the beginning of May. The pike then prefers very shallow water, such as flooded shore areas with rich vegetation. The same spawning place is often used year after year. The eggs are easily accessible for spawn eating animals such as other fishes, predatory insects and their larvae. During the spawning time the pike is relatively fearless, and almost looses its normal reflexes to eat and escape danger. For its continuous development and growth it is of great importance that the pike spawn gets plenty of nourishment during the first days and weeks.

The growth of the pike varies considerably but proceeds on the whole very fast. After just one year a pike may attain a length of 20 cm, and at times a pike only two or three years old may weigh as much as one kg. The females grow faster and become larger than the males. Usually a big male does not weigh more than 3 kg. Very rarely he attains a weight of 8 kg and a length of one meter. In contrast, the females may grow very big and exceptionally attain a weight of 35 kg with a length of 1.5 m by an age of 30 years. Pike may be caught with hook, fyke net, osier basket and net (Lieberkind 1939c, p 120–131, Andersson 1954, p 613–622, Muus & Dahlström 1981, p 14–18, 22–27, 78–80, Bengtsson & Hargeby 1978, p 19). Investigations of ancient fishing in lake Ringsjön, Scania, Sweden, have shown that pike were caught primarily during the spawning season by means of seines, traps made of wicker-work and later in the season with line and hook and leister prongs. The most usual weight of the fishes was estimated to be between 0.5 and 5 kg (Trybom 1893, p 27–28).

Ideal conditions for the pike to thrive were to be found in the vicinity of the pile dwelling during Middle Neolithic times. For instance Lake Tåkern and the Disevid stream offered shore regions rich in vegetation and shallow flooded shore areas suitable during the spawning season. Calm and shallow bays of Lake Vättern may also have been favourable. The pike is highly suitable as food and was probably easily caught, especially during the spawning time. This species is, however, active during the whole year and may have been caught at almost any season. During winter the pike is active in shallow lakes as well as in shoal water, where today the traditional ice-fishing takes place, near reed and other vegetation (Hargeby, pers. comm.).

In the material from the Eastern Trench there are remains of both small and large pike, with a length of up to one meter and a weight of 8–10 kg. Remains of pike have been identified in all earlier analyses of bone material from the pile dwelling referred to in this context and it is on the whole the most common species (Table 80). In his unpublished notes Hedell also points to the presence of both small and large individuals.

The skeleton of the pike is not homogeneously resistant to decomposition and decay since different bone elements have a varying content of cartilage. Specimens

of *dentale* (mandible) and vertebral bodies are considered to be the most resistant parts (Lepiksaar 1982, p 127), including the teeth. The numbers of different bone elements of pike in the material agree well with this statement (Table 20).

7.3.2 Perch (Perca fluviatilis)

Like the pike the perch is a tolerant fish which thrives, above all, in fresh waters but also in brackish water, for instance along the coast of the Baltic. It is a common species in all lowland lakes and also in ponds as long as the access to oxygen is good. It is adaptable to both flowing, still, shallow and deep water and is not tied to the vegetation belt as much as the pike. It is a predatory fish. The younger perch feeds mainly on plankton, insect larvae, bottom living crustaceans, fish eggs and fry. The larger ones eat mainly fish, for example small whitefish, roach and bleak. During the summer season it is often found at the banks in the neighbourhood of tree roots and behind stones. It is a fairly sedentary fish and moves often in shoals. The big perches, however, hunt rather alone. In late fall when the water starts to get cold the perches go together in large shoals and seek out deeper and warmer water. The spawning season usually starts in April but may begin in March depending on the temperature. It lasts into May. On the whole it may start a little later than the spawning time of the pike but lasts later on in May. During this time the perch seeks out shallow areas with rich vegetation of reed, brushwood and roots. The eggs of the perch have a considerably better life expectancy than those of the pike. Every egg is protected, covered by an envelope of jelly, and the percentage hatching is high. In addition hard roe eating animals seem to avoid perch eggs. The reason seems to be of a chemical kind.

Growth is slow and varies with the availability of nourishment. At 5 years of age it has usually a length of 16–17 cm, at 8 years age a length of 25 cm and a weight of 0.8–1 kg. Under very favourable conditions the perch may attain a length of 50 cm and a weight of about 3.5 kg. Usual fishing methods are net, seine, fyke net, osier basket and baited hook (Lieberkind 1939c, p 379–382, Andersson 1954, p 569–576, Muus & Dahlström 1981, p 14–18, 22–27, 156–158, Bengtsson & Hargeby 1978, p 17).

Investigations in the province of Scania, Sweden, during the late 19th century have shown that catch weight could vary between 0.2 kg and up to 2.5 kg. The most usual weight was from 0.75 to 1.5 kg (Trybom 1893, p 22).

Most probably there were favourable conditions for the perch within the region of the pile dwelling during Middle Neolithic times. Both Lake Tåkern, Lake Vättern and probably also larger streams in the region offered good habitats. The perch, which to the modern palate is a delicious meat, was probably a pleasant element in the Alvastra diet. It could have been easily caught during the spawning period by means of net and osier basket for instance. It is active the whole year and may have been caught at almost any season. At the end of the summer and before leaving the shore region in the autumn the perch has attained maximum weight and is thus at its most nutritious (Trybom 1893, p 22). It is assumed that it was not caught to the same extent during wintertime since it then, like the pike, would have been in deep water and less accessible.

There are a few specimens of perch identified in a couple of the earlier analyses of bone material from the pile dwelling (Table 80).

Perch bones are proportionally small but thick, have little fat when fresh and are in general resistant to decomposition (Lepiksaar 1982, p 126). In addition the perch scales have a very characteristic appearance and may easily be identified to species. In the Eastern Trench material the remains of scales and various bone elements from different body parts support such statements (Table 20).

7.3.3 Whitefish (Coregonus species)

It is in general very difficult to distinguish between different species of whitefish, since the genus has a great capacity to develop local distinctive populations. Skeletally the species are to be considered as siblings, very much alike, and it has not been possible to identify the remains in this material to particular species. Principally the whitefish is a cold-water fish existing all over Sweden. It has a predilection for large and deep lakes where the access to clear water rich in oxygen and of a suitable temperature is of vital importance. It may, however, also be found in more shallow, eutrophic (nutritious) lakes, in the Baltic and in river-systems. As regards its food there are two groups of whitefish. One feeds on zooplankton, the other feeds on water-lice, larvae and bottom living crustaceans. Some forms are stationary, others migratory. The spawning season starts in September and ends late in the winter. The period of spawning differs between the species. During the spawning season the whitefish seeks out areas with gravel or sandy bottom either in shallow water close to the shore or running water. The fish then gathers in great numbers. During the warmer summertime this species prefers to be out in the deeper and colder water.

The whitefish is a very meaty and tasty fish and today the coarse-grained hard roe is considered a delicacy. Due to competition and access to food its growth varies a lot. The largest ones may attain a length of 70 cm and a weight of between 8 and 10 kg. During the spawning period it is nowadays caught preferably with a net and in running water also with a landing net. Other fishing methods are the seine and fyke net (Lieberkind 1939b, p 463–467, Andersson 1954, p 662–672, Muus & Dahlström 1981, p 14–18, 22–27, 70–72, Ekman & Iregren 1984, p 29, Hargeby 1985). Investigations of the fishing in Lake Ringsjön in the province of Scania, southern Sweden, have shown that the whitefish was formerly caught primarily during the spawning season by means of nets and that the most usual weight was about 0.2 kg, although occasionally 1 or 2 kg (Trybom 1893, p 26).

The deep Lake Vättern with its clear, cold and oxygenated waters has probably, during Middle Neolithic times as today, formed an excellent biotope in which whitefish could thrive. It may be assumed that whitefish has been an appetizing and desirable contribution to the Alvastra food supply mainly being caught when it was spawning in great numbers near by the shores. If, during prehistoric times, there had been small streams running in the area with outflows into Lake Vättern the whitefish might have, when spawning, migrated up the small streams providing a good chance to fish them easily. Whitefish were certainly active the

whole year but probably would have been difficult to catch during the warm summer periods, since it then prefers to stay out in deep and colder walter. Possibly there was a whitefish population also in Lake Tåkern. However, since the sub-boreal climate gave rise to warmer summers (Berglund 1968, p 46), this was most probably unfavourable to the presence of whitefish in Tåkern (unlike other species, such as bream and tench) (Hargeby, pers. comm.). Hargeby points out that if, during Middle Neolithic times, whitefish were present in Lake Tåkern the whole year, it may have been caught for example by net even in the spring and summer. Consequently the remains of whitefish indicate activity in the pile dwelling particularly during the autumn and early winter, possibly also later in the winter. The possibility that whitefish was caught in spring and summer cannot be excluded. There are no specimens identified as whitefish in the bone material from earlier excavations at the pile dwelling (Table 80).

The whitefish genus belongs to the salmon family *(Salmonidae)*. They are relatively fat fishes, unlike pike and perch. This may to a certain extent explain the insignificant representation of specimens from different body regions. The fat turns rancid, changing to fatty acids which contribute to the decomposition of the fish skeleton. In general specimens of the shoulder girdle, such as the cleithrum, and jaws and vertebrae belong to the harder parts of the skeleton. Hence they are more resistant to both internal and external decomposition (Lepiksaar 1982, p 125–127). The finds of whitefish bone elements from the Eastern Trench support these statements (Table 20).

7.3.4 Bream (Abramis brama)

The bream thrives best in rather warm, slowly running waters rich in vegetation, the so-called 'bream region', existing in broad streams with muddy bottoms, rich in fauna. It also thrives in eutrophic lowland lakes, but which are not too small. The + 12° C-isotherm is the limit for the distribution of this fish in Sweden today. In the lakes it prefers the area of tall vegetation, for example pondweed, just outside the reed belt. In regions where the bream thrives, the pike is to be found and at the borders of these regions also the perch. The bream may also live in river mouths and in archipelago bays of the Baltic. Principally it resides near the bottom, preferring bare areas. Its main food consists of invertebrates. When eating, the bream filters the mud and is positioned almost perpendicularly to the bottom where 'bream holes' may be formed in the mud.

The spawning season may start at the beginning of May and possibly continues into July. It has been noted that the bream may spawn at three different times during this period. During the spawning season small groups of bream gather together into large shoals and seek out shallow water with luxuriant vegetation. This species demands warmth. In the beginning the fry feeds on plankton. Growth is highly dependent on the conditions of temperature and competition. Under good conditions it grows fast. If the conditions are bad it remains small, thin, 'bony' and is called 'young bream'. Since it needs warmth it becomes passive at

low temperatures. When the weather gets cold the bream seeks out deeper water. In wintertime it is inactive. Large shoals, which at times may consist of thousands of fishes, hibernate into deep hollows at the bottom (Trybom 1893, p 29–31, Lieberkind 1939c, p 57–59, Andersson 1954, p 603–605, Muus & Dahlström 1981, p 14–18, 22–27, 122–124, Ekman & Iregren 1984, p 29).

Usually the bream attains a length of 30–40 cm and a weight of 0.5–2 kg. It may, however, reach a length of 80 cm and a weight of 10 kg. The meat is appetizing especially if the fish weighs more than one kg. The bream may be caught by means of net, sein and fyke net. Nowadays the bottom yarn dominates and also the seine in the winter (Lieberkind 1939c, p 58, Muus & Dahlström 1981, p 124). According to investigations of bream fishing in the late 19th century, the most usual weight was between 2 and 5 kg and it was caught primarily during the spawning season, above all by net (Trybom 1893, p 29–31). It is reported that, formerly, in some parishes the fishing during the spawning season was of such importance that people avoided ringing the church bells in order not to disturb the fishes at this time (Andersson 1954, p 604).

It is likely that Neolithic Alvastra streams such as the Disevid stream and also ancient Lake Tåkern, unlike today's, offered favourable biotopes for the bream to spawn, grow and thrive. With the exception of shallow bays, Lake Vättern was probably less favourable (Hargeby, pers. comm.). It has been pointed out that the bream was probably in general more abundant in prehistoric times, about 5000 years ago. In northern Sweden for instance, it exceeded its present limits of distribution. The reasons are considered to be several, that is, higher temperature, greater amount of free nutrients in the water and higher productivity and diversity of plants (Ekman & Iregren 1984, p 29). Hence in the fresh water fauna access to well-fed bream has probably been very good and has probably been a valuable protein source. There is good reason to assume that it was easily caught, primarily during late spring and summer, by means of nets and also traps. This species has the habit of using the same spawning places year after year (Trybom 1893, p 30). Such behaviour may have facilitated the ease of catching. In addition it is a tough fish, which may have made it easier to transport back alive, and been an advantage to fishing peoples.

Owing to its way of life this species was probably extremely hard to fish in winter. Hence the remains of bream probably indicate activities at the site especially in late spring and summer. There are a couple of bream fragments identified in bone material from earlier excavations at the pile dwelling (Table 80).

Like the whitefish the bream is a more fat fish than pike and perch which means that the skeleton in general, especially less solid parts, may decompose more rapidly. The remains of bream signify this, since there are only single fragments left from elements other than the vertebrae in the material (Table 20).

7.3.5 Tench (Tinca tinca)

The tench thrives in the same regions as the bream. It is a hardy fish and endures water deficient in oxygen better than most other fishes and is a typical inhabitant of rather warm waters with luxuriant vegetation and soft muddy bottoms. It is a fairly timid fish living at the bottom and seldom moves up to the surface. At daytime it is less active and hides in the dense vegetation. This behaviour makes it difficult to observe. At the approach of darkness it gets active and starts to feed on invertebrates, such as insect larvae, worms and molluscs. If the spring is warm, the spawning season may start by May, otherwise not until June and continues into July. The spawning often occurs on several occasions during a longer period and takes place in shallow water with abundant vegetation. In the beginning the fry feed on plankton. By the end of the autumn the bream gets more and more passive and ceases feeding. In winter it hibernates to the bottom and becomes half hidden in the mud. It may even survive if it freezes solid.

The growth of the tench is generally slow. In many Swedish lakes it attains a length of 40–50 cm and a weight of 1–1.5 kg to 2 kg. It may exceptionally attain a length of 70 cm and a weight of about 8 kg. The meat is not very compact but is tasty. In Sweden, however, it now has a reputation to have a muddy taste and is not especially appreciated as an edible fish. During the spawning season it is easily caught by means of an osier basket or fyke net. In spring, summer and fall it is caught by baited hook. (Lieberkind 1939c, p 42–44, Andersson 1954, p 591–592, Muus & Dahlström 1981, p 14–18, 22–27, 104–107, Hargeby 1985).

Lake Tåkern and possibly also the shallow bays in Lake Vättern may have offered suitable biotøpes for the tench to thrive during the Middle Neolithic. In the past there may also have been other favourable watercourses, such as slow flowing streams. Compared to the remains of bream those of tench are few in the identified material. The reason may be of a stochastic nature due to sample size and a heterogeneous distribution of the identified species. There are, however, other factors to consider. Possibly the conditions for the tench to thrive were not as favourable as for the bream and, thus, the access to tench not as good, making the fishing of bream or other fishes more profitable. Furthermore, the tenches reserved way of life may have made it more difficult to catch, except, probably, during the spawning period. There may be various reasons why the Alvastra people did not bring tench to the site, preferring instead to consume other fishes. However, it has been reported that earlier groups may easily have avoided the possible muddy taste by not catching the tench during the hot summer months (Hargeby, pers. comm.). This may of course have further limited the fishing period. Otherwise the tench is, like the bream, tough on land and may very well survive to be transported (Muus & Dahlström 1981, p 106).

Due to its long inactive time and hibernation period from late autumn to rather late in the spring, the tench was probably inaccessible to human groups at this season of the year. The remains of this species may thus indicate activity in the pile dwelling area especially from late spring and summer.

There are no specimens identified to tench in the bone material from the earlier excavations of the pile dwelling (Table 80).

7.3.6 Roach (Rutilus rutilus)

The roach is commonly one of the most abundant fishes in eutrophic lakes and slowly running and oxygenated water. Today it is present all over Sweden. It is a shoal fish and thrives in the 'bream region' of the streams, as well as in the innermost reed belt and tall vegetation of the lakes. The largest roaches swim furthest out in the habitat. In highly nutritious lakes it moves all over the lake. Shoals of roach may also be found in faster running streams, where the ide thrives for instance. The roach is hence moving over wider areas than the bream, tench and also the ide. In the fresh water region it is sedentary. It may also thrive in brackish water, for instance in the archipelago of the Baltic. In these waters it is migratory and anadromous (ascending the rivers to spawn and spend the winter).

The roach is tolerant in its choice of food. The food consists of both invertebrates (for example crustaceans, molluscs, insect larvae and plankton) and also of parts of decaying plants and diatoms growing on reeds, poles and stones. The roach may thus be considered to be an omnivore which of course facilitates the adaptability of this species to various biotopes. Depending on the water temperature the spawning season falls in April–May or at times in June. It falls in general later than for pike, perch and ide. The spawning occurs in shallow waters, near the shores. Some populations may also ascend inflows to spawn. However active during the whole year, the roach strikingly reduces its nutritional intake in the wintertime and large wintering shoals stay in deep water.

The growth is in general slow. Usually, under good conditions, the roach attains a length of 20–30 cm and a weight of 1 kg. According to investigations of roach fishing in Scania, Southern Sweden, during the late 19th century, roaches weighing more than 1 kg were caught. The meat is rather 'bony', since species such as roach and ide apparently have a great surplus of ribs, a fact which is explained by the ribs being extremely thin and distally split. All the same the roach formerly had considerable importance as an edible fish and in the Eastern Europe it still has. Today fishing is by net, seine, osier baskets and fyke net (Trybom 1893, p 28–29, Liberkind 1939c, p 45, 47–51, Andersson 1954, p 593–594, Muus & Dahlström 1981, p 14–18, 22–27, 86–88).

A lake forms, more or less, a self-supporting system depending on its inflows and outlets. In the economy of this system the roach plays an important role. It transforms the bottom fauna and parts of plants. It serves as food both for valuable edible prey fish such as pike, perch and wels, and also for heron and otter. There are losses of energy between every link in a nutritional chain. The longer the nutritional link the greater amount of plant material, plankton, insect larvae, molluscs, small fry and so forth are needed to create the last part of the link. In the lakes the last part may be the pike. It seems that in many waters 90 % of the pike's food may consist of roach. This means, in principle, that the production of predators will never be as great as for instance the production of roach (Lieberkind 1939c, p 51, 54, Muus & Dahlström 1981, p 86, 88, 213–215).

The roach has probably been frequent in both Lake Vättern, Lake Tåkern and streams in the area during the Middle Neolithic. However, the remains of roach

are few in the bone material from the Eastern Trench. This may, in its turn, depend on both taphonomic and other reasons. It should be stressed that generally fish bones are relatively small and may easily have been consumed by both man and other animals at the same time as the fish meat. For instance in the inland parts of Northern Sweden the roach was formerly often preserved and then eaten as 'sour roach' (Hargeby, pers. comm.). Besides being a likely part of prehistoric diets the roach has also been an excellent and useful bait fish (Muus & Dahlström 1981, p 88). Since the roach is active during all seasons it may have been caught the whole year round. The best, most abundant and easiest catch has, however, probably taken place by means of nets during the spawning season, as once in Lake Ringsjön (Trybom 1893, p 29).

There are no remains identified to roach in the bone samples from earlier excavations of the site (Table 80).

7.3.7 Rudd (Scardinius erythrophthalmus)

The rudd thrives in the same waters as the roach. It means the 'bream region' of the streams and the reed belt and taller vegetation of eutrophic lakes. Unlike, however, the roach it is present nowadays only in southern Sweden. On warm and sunny days it has a predilection to stay near the surface near the sun. Ecologically it may be considered to be a less demanding species. The main food consists of plants, both fresh, faded and decaying. It has been suggested that this species is the only one among our fresh water fishes which, when adult, mainly lives on plants. The rudd adds to this food with invertebrates and fry. It is a relatively sedentary fish living in small shoals, sometimes in company with other carp fishes.

The spawning season falls relatively late in spring to early summer. The time is highly dependent on the water temperature. Usually the spawning takes place during May to June, often in the middle of June, thus later than among fish such as roach. During the spawning the rudd seeks out calm and shallow water with luxuriant vegetation at the bottom. Sometimes it mingles with other carp fishes spawning and can create hybrids together with roach, white bream and others. The fry feed on plankton. Since the rudd is a warmth demanding species, it gets inactive in late autumn when the temperature falls. The winter season is usually spent in deeper and warmer waters.

The growth is slow. Not until about 10 years of age has the rudd attained a length of 20 to 30 cm and a weight of 200 to 400 g. The meat is 'bony' and the rudd is today considered to be without value as an edible fish. Also formerly it seems to have had limited popularity as an edible fish (Trybom 1893, p 29, Lieberkind 1939c, p 46, 52–54, Andersson 1954, p 598–599, Muus & Dahlström 1981, p 14–18, 22–27, 100).

Consequently the rudd probably did not play an important role as an edible fish and protein resource for the people who used the pile dwelling, but it cannot be proved that rudd was not consumed. It may have accompanied more edible fish, such as bream, when traps and nets were examined and then brought to the site accidentally, thrown away and consumed by dogs, birds and other scavengers. Probably it may also have been caught intentionally by means of baited hook in

Lake Vättern near the shore, in Lake Tåkern and in streams, since it is a good bait fish and, unlike the roach, tough on land (Muus & Dahlström 1981, p 100).

Since the rudd is inactive from late autumn to the spring the remains of this species may indicate activities in the site during the warmer season of the year. No remains of rudd have been identified in previous analyses of bone samples from the site (Table 80).

7.3.8 Ide (Leuciscus idus)

Unlike the bream and the tench, the ide prefers deeper and more rapid-flowing regions of streams where the bottoms are soft and rich in vegetation. In these areas shoals of roach and rudd as well as perch are also living. The ide thrives also in several lakes and in brackish water along the coasts. Nowadays it has a distribution all over Sweden. In fresh water it feeds mainly on insects. In brackish water the food consists mostly of crustaceans and molluscs. In a way it may be compared to a predatory fish since older individuals eat other fishes, such as roach. Like other carp fishes, such as bream and tench, the ide forms sedentary populations in fresh water and migratory ones in brackish water. The migratory populations are, like those of roach, anadromous. Also the populations in lakes may ascend inflows to spawn.

The spawning season falls relatively early in spring, around the month of April. Depending on the temperature it may start in March. During this time the ide seeks out areas with running water and gravelly, stony bottoms. The fry leave for calm water and live in the beginning on plankton. The ide is active from spring to fall. During the winter season it remains passive, staying in deep water. Usually it attains a length of 30 to 40 cm and a weight from 700 to 1300 g. Main fishing gear today consist of the seine, net and net traps (Lieberkind 1939c, p 46, 51–52, Andersson 1954, p 595–597, Muus & Dahlström 1981, p 14–18, 22–27, 96–97, Hargeby 1985). In Gotland, an island in the Baltic, it is often caught by landing-net or angled during the spawning season (Hargeby, pers. comm.).

Both Lake Tåkern and Lake Vättern and associated inflows may have offered suitable biotopes for the ide during Middle Neolithic times. The ide was probably easily caught, primarily in the spawning season and especially when ascending the inflows to the lakes. The meat of the ide is rather 'bony' but quite edible. Today, in Gotland, the meat is usually prepared to minced fish (Hargeby, pers. comm.). In addition this carp fish is, like bream and tench, tough and may easily have been kept in a fish-chest or transported.

Since the ide is passive during the winter season it was to a large extent inaccessible to the Alvastra people during this time period. The find of ide may thus indicate activities at the pile dwelling sometimes between early spring and late autumn. There are no remains of ide identified in bone material from the earlier excavations at the site (Table 80).

7.3.9 Summary and comments

An attempt will be made to estimate the degree of seasonal utilization of the pile dwelling by using the identified fish remains. It is assumed that, in prehistoric times, most fishing generally took place during the period when the identified species were abundantly present and most easily caught (Aaris-Sørensen 1978, p 21, Larsson 1983, p 121–122, Ekman & Iregren 1984, p 28–30, 36). Considering this and the above-mentioned descriptions of each species identified in the material, the result ends up on one hand in the spawning period of each species and on the other seasonally from early spring to late autumn. There is however one exception, the whitefish, which may spawn also during the winter season. The result is shown in Fig.27.

Fig. 27. SPAWNING SEASONS for FISH SPECIES identified in the Eastern Trench material.

Consequently it can be argued that busiest fishing period of the majority of edible species identified in the material from the Eastern Trench probably started in March and continued through the summer. The pike, perch, whitefish and roach are active during the whole year, while the bream, tench, ide and also the rudd are inactive during the cold season. Probably the catching of both pike, perch and roach continued through the autumn. During winter all three may have been less accessible to man, since at least the perch and roach spend the winter away from shore seeking out deeper and warmer areas in the lakes. According to Trybom (1893, p 22–23), it is however possible that perch fishing was rather successful most of the year, and ice-fishing of pike may have taken place successfully in Lake Tåkern during winter. The whitefish in contrast has been less accessible in the warm period, since it then seeks out deeper and colder parts of the lakes. It may be noted that fish species such as whitefish, which are spawning

during autumn and also early winter, do not regain weight until the following summer (Trybom 1893, p 22).

Except for the roach, all carp fishes identified in the material are warmth demanding species and become inactive during wintertime. As soon as the temperature falls in the autumn they get more and more passive, seeking out deeper, warmer water and hollows in the bottom where they hibernate during the winter. It is assumed that the edible fishes, bream, tench and ide as well as the rudd, were practically inaccessible to man from about late autumn during the whole winter and at least until spring. Some, for example the bream, gather in large shoals during the cold season. It has been pointed out that such aggregations were formerly caught in large quantities by means of seine (Andersson 1964, p 605). Ekman, however, has stressed that prehistoric people, if they were at all familiar with such methods, would most certainly not have used them in relation to a valuable food fish. For such fishing could have totally wiped out the breeding population for the next season (Ekman & Iregren 1984, p 30).

In view of the fact that the spawning season is a highly suitable time for fishing, it should be further emphasized that some valuable edible carp fishes, such as the bream and also the roach, spawn making a lively splashing (Muus & Dahlström 1981, p 86, 124). This has certainly assisted the detection of the populations of these species.

To sum up, identified fish remains may thus indicate a period of considerable activity at the pile dwelling from early spring, over the summer and on towards autumn,with perhaps peaks of fishing in March–April and May–June time related to the spawning season of the most frequent species in the material, pike and bream. The remains of perch and pike in particular could indicate continuing activity during the winter, as also could the remains of whitefish, since spawning in this species may have gone on into January.

Remains of pike, bream and also perch have been identified in the bone samples previously analysed from the site. On the other hand remains of wels *(Silurus glanis)* and white bream *(Blicca bjoerkna)* (Table 80) are not represented in the bone material from the Eastern Trench (Table 6). Specimens of wels are present in the majority of earlier analyses. There is, however, only one find of white bream (Table 80).

The Swedish wels is a member of the wels family *(Siluridae)* which belongs to the large taxon of carp fishes *(Cypriniformes)*. It is a warmth demanding species which spawns in the summer, during July and August, and becomes passive during the autumn with, in consequence, a reduced nutritional intake. In the wintertime it hibernates down at the bottom. It is a large voracious predatory fish, only active at night in shallow waters. The wels can seriously damage populations of edible fish such as bream, tench and roach within an area, especially during the spring when the nutritional intake is at its greatest. The meat is practically 'free from bone' and very tasty. It is in general a solitary species, but lives in pairs during the spawning (Lieberkind 1939c, p 13, 78–80, Andersson 1954, p 611–612, Muus & Dahlström 1981, p 144–146). It can be assumed that the wels was caught primarily during the spawning season in the summer and possibly also in spring and autumn.

The white bream is a member of the carp family *(Cyprenidae)*. Its spawning time falls in May to June and may in Scandinavia go on into July. Like most of the carp fishes identified in the material it demands warm conditions and gets inactive when the temperature falls in the autumn. During winter it stays passive at the bottom. It ressembles the bream a lot. However, unlike the bream, the meat is not so tasty. Today it is not considered to be a very edible fish. When catching bream the whitefish often appear as an accessary catch (Lieberkind 1939c, p 59, Andersson 1954, p 605–606, Muus & Dahlström 1981, p 120–121). Possibly the only find of white bream in the previous bone samples from the pile dwelling may have got there for this reason.

Hence the finds of the edible and tasty wels as well as the white bream fit well into the picture of activity at the pile dwelling which has been suggested above.

The most likely fishing tackle, used by the Middle Neolithic people in Alvastra, was probably various fish traps such as the osier basket, as well as fyke net, net, landing net, hook and line and leister. Finds in the province of Scania, Sweden, from Mesolithic and Neolithic times of fishing tackle, such as hooks, osier baskets, nets and wicker traps, have previously been studied (for example Lekholm 1951, Pettersson & Olausson 1952, Stjernquist et al. 1953). It has been recorded that, formerly, the pike was often caught by leister both with and without the light of a torch (Trybom 1893, p 28).

The presumed frequent under-representation of fish bone remains in both Neolithic and Mesolithic bone samples has been discussed and emphasized in some previous analyses of Swedish fish bone remains (for example Ekman 1974, p 213–214, Lepiksaar 1974, p 154–156, 1982, p 126–128, Larsson 1983, p 131). The reasons are assumed to be several and may be explained in many ways. One reason is the technique used during the excavation. The importance of a meticulously careful excavation by means of water-sieving and also sediment/soil sampling has been previously underlined (Payne 1975, 13–17, Clason & Prummel 1977, Aaris-Sørensen 1978, p 12, 1980, p 141–142, Larsson 1980, p 18, 1983, p 131). As already pointed out the animal bone sample from the Eastern Trench has not been biased by the neglect of such measures (Chapter 1 and Section 7.3). Compared to the heavier bones of mammals and to a lesser degree of birds, the dry, small, thin and light-weight bones of fish may quite simply blow away from their original site position. Consequently fish remains are, from the beginning, more easily fragmented and exposed to various taphonomic factors in the surrounding environment as well as by human and animal activity. To illustrate the possible under-representation of fish bone elements, calculations have been made (Lepiksaar 1974, p 153–155) which are based on the estimated numbers of individuals and on the numbers of individual bone elements from complete skeletons of the species in question. The examples will be given by reference to material from the Eastern Trench.

In the sample it is assumed that there are the remains of 9 pike. Each pike has 61 vertebrae. The expected number of vertebrae is thus 549. There are 14 finds of pike vertebrae in the sample. This gives an under-representation of vertebrae of

97 %. There are remains of 6 perch each originally with 42 vertebrae, giving an expected number of vertebrae of 252. The finds of perch vertebrae are 8. This results in the same under-representation, 97 %. It is estimated to be remains of 8 bream. Each bream has 43–45 vertebrae (Harder 1975), giving an expected number of vertebrae of about 352. The finds of bream vertebrae were originally 88, as regards the statistical evaluation 116. This results in an under-representation of 75 % and 67 % respectively.

The cleithrum is a bone element in the shoulder girdle. These bones are paired. There are 4 specimens of cleithra identified as pike, 3 as perch and 1 as whitefish in the sample. It is suggested that there are remains of 5 whitefish in the material. This results in under-representations of 78 %, 75 % and 98 % respectively. Finally the jaw bone *(dentale),* which is also a paired bone. There are 18 specimens of *dentalia* identified as pike and 2 as perch in the remains. In this case the results for the two species are quite different. It gives 0 % under-representation for pike and 83 % for perch.

The results stress that resistance to decomposition is not usually homogeneous among different elements in the fish skeleton, nor among species, and that some bone elements may have been more easily chewed to pieces or consumed than others.

More than 50 %, 186 fragments, of the identified fish remains consist of vertebrae (Table 20). This may to a certain extent depend on the fact that vertebrae are proportionally more resistant than many other fish skeletal elements (Lepiksaar 1974, p 154, 1982, p 127) but equally on the fact that they are present in a great number in each individual skeleton. Consequently there is a good chance of finding and identifying preserved vertebrae, more so than for most of the single or paired individual fish bone elements. This may seem to be in contradiction to what has been stated earlier, that is, that the under-representation was great among vertebrae. This may, however, be partly explained by the fact that to get at least a fairly good percentage representation of vertebrae per species, many vertebrae need to be identified to particular species in relation to their great number in the complete skeleton.

As mentioned in Section 7.3 the remains of fish are relatively few in the bone material from earlier excavations of the pile dwelling. On the basis of the results from the Eastern Trench an attempt is made to estimate the numbers of fish bone fragments in these previous samples. The estimation results in a pronounced augmentation of the number of fragments. There are 429 specimens of fish identified from the Eastern Trench (with an area of about 15 m^2), giving a mean value of about 29 fragments per m^2. There are a little more than 100 specimens of fish identified in the bone material from the former excavations. According to the excavation plans the excavated area covered about 625 m^2, about two-thirds of the total area of about 1000 m^2 (Malmer, pers. comm.). Supposing that, by using modern techniques such as water-sieving, the frequency of fish bones for the area dug was approximately the same as for the Eastern Trench, this means that there would have been 18125 specimens instead of about 100 specimens!

If we proceed a step further and make an approximate fish bone estimate for the total area of 1000 m², this gives a result of about 29,000 specimens. In both cases it has been taken for granted that the frequency of fish remains is equal all over the area. This is probably not the case. It is more likely to vary from possibly a few fragments to more than 29 within one m² which in reality it does in the Eastern Trench (Fig. 8). But even so the estimates increase the number of fish bones to a very great extent.

In view of these results, as with others in the study, it is stressed that they have to be considered with caution, since the basis for the estimations is just a sample of a much larger bone total. The estimations, however, clearly underline the difference in results achieved by using modern excavation techniques and ones achieved by using oldfashioned techniques. The results also show that the remains of fish in the earlier analyses probably do not reflect the real role of fishing in this Middle Neolithic inland economy. Fish were clearly a valuable source of protein and an important contribution to human diet.

7.4 Comparisons with today's fauna and biotopes

The province of Östergötland and the Alvastra region in particular show far more open scenery today than in the Middle Neolithic. Nevertheless, many of the wild mammals identified in the bone material from the Eastern Trench and other samples from the pile dwelling still exist in the locality, namely elk, red deer, roe deer, badger, pine marten, mountain hare, red squirrel, ground vole, field vole, common shrew and hedgehog. Ecological conditions are still ideal for the wild boar but this species no longer lives freely, since it is too much of a nuisance to farmers. There are no brown bears in the area any more and neither is there a stationary population of wolves. The lynx is present in very small numbers in coniferous areas of Östergötland. This species needs vast home ranges and in fact a favourable biotope is at present absent in the Alvastra region. South of Lake Tåkern, in the Disevid stream, there was still a beaver population in the 19th century and in the Omberg area the otter was present at that time. Now these species do not exist in the region (Enqvist, pers. comm.).

As regards the wild mammals which are present in the area today but are not identified in the pile dwelling samples, they are represented by the red fox *(Vulpes vulpes)*, the stoat *(Mustela erminea)*, the polecat *(Mustela putoris)*, the weasel *(Mustela nivalis)*, the pygmy weasel *(Mustela rixosa)* and the mole *(Talpa europaea)*. Moreover, there is the bat family *(Vespertilionidae)*, other members of the shrew family *(Soricidae)* and various rodents *(Rodentia)*, such as the dormouse *(Muscardinus avellanarius)*, the house mouse *(Mus musculus)*, the common red-backed vole *(Clethrionomys glareolus)* and the brown rat *(Rattus norvegicus)*. Factors such as sample size and the heterogenous distribution of bone material over the site may, of course, have caused the lack of fur animals, such as red fox and stoat in the material. Other factors, such as periodic fluctuations in numbers of animals and diseases of an epidemic kind may also have affected the presence of some species in the material (Section 2.2). Moreover, it may be assumed that the

Alvastra people had no interest in hunting small mammals suh as moles, bats and rodents. In the case of the brown rat, it probably did not spread from eastern Asia across Europe until the mid-sixteenth century A.D. (Clutton-Brock 1981, p 154). According to Ekman (1922, p 370–371) the house mouse and the small Swedish dormouse have existed in Sweden since Boreal times. In his survey of subfossil vertebrate finds from the province of Scania, southern Sweden, Liljegren (1975) only mentions finds of dormouse, flemming and three species of voles, but not the house mouse. The finds of dormouse come from Husie parish and are dated to the Late Neolithic/Early Bronze Age (Schnittger 1910, p 31 from Liljegren 1975, p 45). The dormouse is today represented by six living genera in Europe and Asia and in ancient times the fat dormouse *(Glis glis)* was at times kept in captivity and eaten by the Romans (Zeuner 1963, p 415). In the case of the house mouse, remains of this species were reported from Eketorp ring-fort II, Öland, dated to 400–700 A.D. (Boessneck & von den Driesch 1979, p 204, 215).

There are also species in the area which are not native to Sweden but became naturalized during the late 19th century and later. Such animals are the brown hare *(Lepus europaeus)* and the American mink *(Mustela vison)* (Siivonen 1976).

Among zoologists the general opinion is that the number of bird species in the area has continuously increased since the Pleistocene. During the latter part of the 19th century, especially after the subsidence of the water-level in Lake Tåkern between 1842 and 1844, the numbers of species increased very substantially. Later, at the beginning of this century, continuous periods of dry weather temporarily decimated some of the waterfowl. In the 1950s the presence of a great quantity of phosphorus further reduced the number of waterfowl. In the 1960s there was a distinct improvement of the bottom vegetation. At the same time as there was some regulations of the water-level in the lake, in 1966, a rise in the numbers of waterfowl began. The earlier subsidence in the 1840s combined with this new regulation of the water-level gave rise to a strong growth of vegetation and after 1966 two new kinds of important charaphytes immigrated. Lake Tåkern is today among the richest in bird species in northern Europe (Ekstam 1975).

All bird species which have been identified in the Alvastra bone material are still present in the locality, with one exception, the capercaillie. This species favours older coniferous forests and tree felling and cultivation of the landscape have contributed to its disappearance. Today, the crane and pintail, together with the whooper swan, migrate and do not breed locally, while the teal, wood pigeon, meadow pipit, tree pipit, honey buzzard, marsh harrier, woodcock, mallard and tawny owl all are breeding birds in the Alvastra area. Also the greylag goose can breed in the Lake Tåkern area. The crane is found breeding today in Holaveden, the woodland situated about 25 km south of Lake Tåkern. The heron, mallard and tawny owl are wintering species. Occasionally the golden eagle is wintering although not breeding (Enqvist, pers. comm.). (For Latin names of the birds see Tables 19 and 79.)

The Alvastra region of today offers ecological conditions which are very favourable to the teal, mallard, tree-pipit, woodcock, marsh harrier and tawny owl. The marsh harrier is today a typical bird of the area. In fact the greatest

number of marsh harriers in Sweden is to be found at Lake Tåkern. The ancient Lake Tåkern was probably not that rich in reed areas and the marsh harrier thrives especially well where there are vast reed beds with good access to frogs, insects, fish and small rodents (Cramp & Simmons 1977, p 106–107).

Various small birds are the most frequent species in the area today. Common birds also include ducks *(Anseriformes),* grebes *(Podicipitiformes),* wading birds and gulls *(Charadriiformes),* crows *(Corvus corone cornix)* and jackdaws *(Corvus monedula),* the latter being common in cultivated landscapes. A review of numbers of species found at Lake Tåkern has revealed the occurence of 249 different species. In 1980 about 100 of these species were breeding regularly and a further 25 were breeding temporarily (Tyrberg 1980). As an example of the numbers of birds passing during migration, which may land periodically to feed, the number of bean geese may be noted. During the autumn between 20,000 and 40,000 bean geese pass through (Enqvist, pers. comm.).

This great number of species noted today in the area stresses what has already been pointed out (Section 7.2.8) namely, that the assortment of different species was probably considerable in the Middle Neolithic thus providing the Alvastra people the opportunity to be more selective and choose special birds for special purposes. The presence of an abundant bird fauna helps to explain why so many different species have been identified in the different bone samples from the site.

Concerning fish species represented at Alvastra, wels *(Silurus glanis)* are today neither present in Lake Tåkern nor in streams close by. In general the wels populations, which still exist in Sweden, are considered as relict populations from a warmer climate. Nowadays the wels is only certainly present in the streams *Emån* and *Helgeån* in the provinces of Småland and Scania and in Lake Båven in the province of Södermanland (Hargeby, pers. comm.). As regards the composition of the fish fauna in Lake Tåkern today, the species bream, silver bream, whitefish and ide are not to be found. Some decades after 1844–1846 when the lowering of the water-level took place, at least the bream was still present in the lake. On the other hand by the end of the 19th century there was no tench. This species seems to have disappeared sometime between the time of the pile dwelling and the present. A colder climate and changes in the vegetation may both have contributed to its disappearance. The present tench population comes from an introduction of the species in the 1930s. Today the tench is a species characteristic of the lake. Pike, perch, roach and rudd all seem to be fairly well represented. As regards species present in the fish fauna today but not identified in the Alvastra material there are eel *(Anguilla anguilla),* burbot *(Lota lota),* ruffe *(Acerina cernua)* and crucian carp *(Carassius carassius).* At the beginning of this century there was plenty of burbot in Lake Tåkern. After a couple of very hot summers in the thirties, the burbot population was reduced and has since then greatly diminished due to a continuing deterioration in available oxygene in the winter. Probably this species will be the next to disappear from the fauna. Also the eel occurs rarely. The crucian carp has probably been introduced during historic times by, for instance, the Medieval monks. Today the crucian carp is one of the most frequent fish

species in Lake Tåkern. The regulation of the outlet of Lake Tåkern into the Mjölna stream has prevented the movement of fish into the lake. In actuality the lake passes through a slow transformation from lake to swampy ground to marsh-land. The ancient lake during the Middle Neolithic was probably about 6 m deep. In many ways it was similar to Lake Roxen today, which also is situated in the province of Östergötland (Hargeby 1985). It seems likely (Hargeby, pers. comm.) that eel, burbot and ruffe were present in Lake Tåkern during later prehistory. The reason why there are no remains of these species represented in the Alvastra sample (Tables 6 and 80) may of course be of a stochastic nature. There are, however, other possible reasons. For example today, the ruffe is not considered to be an especially attractive food fish, the eel is a fat fish and thus has a less resistant skeleton in terms of preservation and the burbot is mainly active at night, spawns in the winter and is then most easily caught. Possibly the lack of burbot remains in the samples indicate less human activity at the pile dwelling during the winter.

All the species, pike, perch, whitefish, bream, silver bream, tench, roach, rudd and ide, which have been identified in the pile dwelling bone sample, are today present in Lake Vättern. The present whitefish is the common whitefish *(Coregonus lavaretus)* (Wendt 1968). As regards the pike it occurs locally. In addition the lake is ecological ideal for many other species. Besides the above mentioned ones the following species occur nowadays in Lake Vättern (Wendt 1968):

Bleak *(Alburnus alburnus)*
Bullhead *(Cottus gobio)*
Siberian bullhead *(Cottus poecilopus)*
Fourhorn bullhead *(Oncocottus quadricornis)*
Burbot *(Lota lota)*
Char *(Salvelinus alpinus)*
Crucian carp *(Carassius carassius)*
Eel *(Anguilla anguilla)*
Grayling *(Thymallus thymallus)*
Loach *(Cobitis taenia)*
Minnow *(Phoxinus phoxinus)*
River lamprey *(Lampetra fluviatilis)*
Ruffe *(Acerina cernua)*
Smelt *(Osmerus eperlanus)*
Ten-spined stickleback *(Pungitius pungitius)*
Three-spined stickleback *(Gasterosteus aculeatus)*
Trout *(Salmo trutta lacustris)*
Vendace *(Coregonus albula)*

The lake is deep, 120 m, and large, 1900 km², and has different environments which make it possible for glacial relicts, such as char and fourhorn bullhead, to live in the same lake as bream. It seems likely that Lake Vättern was as rich in fish species during the Middle Neolithic as it is today. It cannot be ruled out that the species listed above (except the crucian carp) had already moved into the lake by that time (Hargeby, pers. comm.). Many of these species are not identified in the samples from the pile dwelling. Various reasons may be involved, besides the

heterogeneous distribution of material. First of all the area of Lake Vättern, close to Alvastra and Lake Tåkern, represents a type of biotope which well suits the species identified in the Alvastra material. Furthermore, several of the species, such as bullhead, stickleback, minnow, bleak and river lamprey, are not particularly edible fish. Others, such as grayling, a good edible fish, live in another area (biotope) of Lake Vättern, tens of kilometers away from Alvastra and the pile dwelling.

8. Main results and conclusions

The main purpose of this study has been to investigate how far one can 'reconstruct' economically and interpret an archaelogical site by the analysis of vertebrate samples from a limited area of the site. One advantage of working with small samples is the enhanced possibility of obtaining results without an excessive lapse of time and, moreover, to test different quantification models without the need for detailed computer support. The bone material considered has been excavated by modern methods supported by water-sieving, meticulously undertaken. The sample was deposited during a very short time period – about 50 years. Furthermore, the area selected, the Eastern Trench, seems to have been in intensive use for a great deal of that time.

In the study different methods to estimate the numbers of individuals of identified mammal species are used in order to compare the methods and the results achieved. The methods used are: 1) the traditional MNI method, 2) an extended MNI, the so-called EMNI method, 3) Krantz's method (1968), 4) Casteel's method (1977), 5) Poplin's method (1978/79) and 6) Lie's method (1980).

In the case of cattle all these methods are discussed. In certain cases the methods give markedly different estimates. As regards the minimum numbers of individuals (MNI), Casteel's method gives in general the highest estimates, while the traditional MNI and also Lie's method give lower estimates (Section 3.5 and Chapter 4).

The traditional MNI method is in many cases considered to give numbers which are far too low compared to what the original population numbers could reasonably have been. According to Perkins Jr. (1973) the use of the MNI method is justified only when several conditions can be met. He makes the following conditions: 1) The sample was deposited during a known period of time; 2) there was a high rate of preservation of the sample making it possible to calculate the actual number of individual animals killed at the site; 3) virtually complete recovery of the faunal sample must be made. As regards the sample from the Eastern Trench, such conditions are judged to be fulfilled, which may indicate that in this case the EMNI method gives a fair estimate of the actual numbers of individuals from which the remains emanate. This should, with respect to cattle, also be valid for the estimates derived from Krantz's (1968) and Poplin's (1978/79) methods, based on the four pairs of radii. A disadvantage of these latter methods is that they are based on the pairing of bone elements, in both methods demonstrated

on mandible halves, whose similarity and fit indicate when they are derived from the same individual.

When handling large archaeological bone samples such a procedure as pairing is in general very difficult, time-consuming and a somewhat impossible task, which often gives uncertain results. Food debris from archaeological sites often consists of exceedingly fragmented bone elements which have undergone hundreds or maybe thousands of years of taphonomic influence. Also, it is important to note that in most cases the bones were deposited during a long time period. This can make such samples unsuitable for pairing procedures.

Like Perkins (1973) I believe that in the case of a long period of occupation, covering hundreds or thousands of years, each bone fragment can reasonably be assumed to come from a different individual (the TNF method). Perkins emphasizes, however, important factors which strongly influence this method negatively. For instance the number of bone elements are not constant between species and butchering techniques and other factors may influence bone survival among species. Grayson (1979) stresses that the method does not discriminate between bone specimens from the same and those from different skeletons. This may be of less importance if one considers Lie's (1980) remark that "many individuals are no longer represented in the excavated material" depending on taphonomic factors.

To demonstrate a possible source of error, when applying Casteel's (1977) method to the Eastern Trench material of mammalian bones, the horn core and cranial fragments of cattle (254 pieces) can be used. Several fragments come from the upper levels of two square meter samples in the north-eastern corner of the trench. These could conceivably belong to the same skull. Taking them into account, but assuming that they come from different individuals in order to apply Casteel's method does not seem reasonably. In order to solve this problem it is possible to suggest the use of a combination of Perkin's (1973) RF method and Casteel's method. This would demand the selection of what Perkins calls a "number of diagnostic bone elements" for each species and then their use in Casteel's formulae for large or small samples.

As regards Lie's (1980) method it requires that the discrepancy between left and right numbers of bone elements chosen diagnostically is proportionally large, that is has a marked skewness, in order to give a result which significantly differs from a traditional MNI estimate. Wild and Nichol (1983) demonstrate statistically that the occurrence of such a marked skewness is a rare event. The importance of Lie's contribution to the MNI discussion is that he carefully considers established statistical methods in the calculation of the minimum number of individuals.

Summing up this discussion, it is important to emphasize that the quality of the bone sample and other site variables strongly affect the choice of method one selects to calculate the numbers of individuals in the sample. With respect to a small bone sample, such as the one from the Eastern Trench with its special qualities, I would argue that the EMNI method probably gives a good estimate of the *number and age* of the individuals which are represented in the remains. Horton (1984) evaluates the various methods used to estimate the numbers of

individual animals from the number of bone fragments found in archaeological assemblages. Contrary to, for instance, Grayson (1979), Horton does not think there is reason to abandon the use of minimum numbers as long as one clearly states the implications of using it. Nevertheless, I would suggest that the MNI in itself has less importance than the relative frequencies of identified species.

Results from methods like the EMNI (Table 21) calculated on a small part of a site area, can at least be used to give a first approximation of the number of individuals one could expect to identify in a bone assemblage from the total area. Applied to the Alvastra pile dwelling with a total area of about 1000 m², the result from the Eastern Trench (area about 15 m²) gives: cattle 667, sheep 267, elks 67, red deers 267, roe deers 67, pigs 467, wolves 67, dogs 67, brown bears 67 (133), badgers 133, pine martens 267, lynxes 67 (133), beavers 67, mountain hares 133, ground voles 133, field voles 67 and common shrews 67 in numbers of individuals. It is, however, emphasized that these figures are only of diagnostic value which is obvious with respect to mammals such as the lynx, represented by just one or very few bone specimens.

In order to undertake a relative quantification of the faunal remains that belong to one of several closely related species, a statistical model has been used (Chapter 5). The model is applied both to mammals and fishes in order to allocate 'grouped material' to species. This means that in general the relative frequency of bone material identified to particular species will be increased in the material both with respect to number and tentatively also to weight. As regards the relative frequency of cattle it increases from 28.5 to 48.5 % by number and from 63 to 75.5 % by weight. As regards sheep it means an increase from a little more than 1 to 6 % by number and from less than 1 to about 2 % by weight. In the case of the big cervids, elk and red deer, it means an increase from 4.5 % to more than 8 % by number and from 8.5 to 11 % by weight. In this case it is likely that the main part of the allocated 'grouped material' belongs to red deer, being far more frequent than elk in the material originally identified to species. Also in the case of roe deer the result shows a slight increase in the number of fragments, from about 0.2 to 0.3 %. As regards the identified fish bone material, the relative frequency of bream increases from 26 to about 39 % by number and from 22 to about 28 % by weight. This result makes the bream and not the pike the most common fish species in the material with respect to the number of fragments.

Using the results from such statistical evaluations also has other important rectifying consequences regarding the distribution of the number of different skeletal elements and their identification to particular species. Smaller fragments of specimens from skull, ribs and vertebrae are often difficult to identify precisely to one species, especially if there are two or more skeletally similar species identified in the material. Such fragments are therefore often underestimated quantitatively in the interpretation of the remains and thus some statistical adjustment is called for.

The allocation of the 'grouped material' ('sheep/goat' and 'small ruminants') more precisely to sheep and roe deer changes significantly in the material the relationship between meaty and less meaty areas of their skeletons. It means in fact

that the meaty portion increases, especially since the numbers of vertebral and rib fragments will be increased as illustrated in Fig. 16. Furthermore, the allocation of 15 % of the 'grouped material' ('big ruminants') more precisely to elk + red deer means that these species, probably first of all the red deer, are represented by more elements from the cranium, mandible, vertebrae and ribs, giving a better and more even representation of the nutritious areas. The allocation of 'grouped material' ('carp family') to bream, also gives to some extent a better representation of skeletal elements other than vertebrae, such as skull, ribs and pharyngobranchial bones, as well as scales.

These statistical corrections demonstrate that species such as red deer, sheep and roe deer are probably represented in the material by far more bone elements from various skeletal regions than were first identified in the sample. It therefore seems likely that whole bodies of these animals, as well as of cattle, were brought to the site. Such a statement would hardly have been possible without the statistical modifications.

Furthermore, when dealing with the special problem of the sheep/goat group, a formula (4) (Section 5.5) was applied which made it possible to allocate, with a confidence level of 95 %, 93–100 % of all fragments identified as sheep/goat to sheep only. In order to allocate fragments from the 'small ruminants' group to sheep, goat and roe deer, a two-step procedure was used, each part of which considers two species/groups only. Since, for simplicity, only estimated values (point estimates in statistical terms) are considered as a rule, no fragments have been allocated to goat. (Section 5.6).

Consequently, by using the statistical approach undertaken in this study on the sheep/goat material, it has been possible to leave out the goat when quantifying the bone material from the Eastern Trench. It is here argued that this has been of great advantage to the interpretation of the material since, so far, the goat has not been identified with certainty in bone material from the pile dwelling at all. Generally, to be able to evaluate more clearly the importance of sheep *or* goat in archaeological bone samples, enables a more reliable interpretation of the environment and economy. The sheep is a grazing ungulate while the goat is a more hardy and browsing animal, perhaps the most versatile of all ruminants (Clutton-Brock 1981, 57–58). From the beginning of their introduction to northern Europe they seem to have filled different economic functions, the sheep being mainly a meat producer and the goat mainly a milk producer (Lepiksaar 1963, p 33). Another interesting result of the application of a statistical model is the prospect of distinguishing truly domestic animals from wild ones in the region. This is clearly of importance when interpreting the life and economy of prehistoric communities.

The study in fact shows that animal husbandry probably played a vital part in the life and economy of the Middle Neolithic people of Alvastra. Cattle-raising seems to have been the most important producer of meat in view of the amount of bone material. The rather few remains of sheep indicate a less important role for this species. Wild boar and early domestic pig seem to be nearly as important a resource as cattle, but with one exception, Ekman's material (1977). However,

according to Ekman (pers. comm.), it is likely that this bone sample is a selected one and thus needs not be representative of the bone material as a whole. In Ekman's data the red deer is the most common species. Indeed, the remains of red deer are rather frequent in all other bone samples, indicating that this species had the most economic value among the cervids. In comparing this study with the earlier analyses there are also other distinct differences, such as the frequency of roe deer and fish remains. The roe deer seems to be more frequent in general than the remains from the Eastern Trench indicate. The reason for this may very well depend on the probably heterogeneous distribution of material over the site area. In view of the fish bones they are relatively few in previously analysed material but not so in the Eastern Trench material, probably due to the modern excavation technique. Consequently, the evaluation of the fish bone material in Section 7.3.9 suggests that fish constituted a valuable component in the Alvastra people's economy.

In the case of the frequency and distribution of different bone elements, the investigation and statistical evaluations show that the material from the Eastern Trench includes parts from most skeletal areas of the meat producing mammal species. This may indicate that the bodies were butchered on the spot, that is, not outside the site. Alternatively, they were butchered elsewere, but then most parts were brought to the site to be consumed. Most probably a big animal such as the elk was butchered, for practical reasons, near the place where it was killed. Fur producing mammals were also represented by most parts of the skeleton. This overall conclusion that most mammals were in fact represented by many different bone elements from various parts of the skeleton does not seem to be contradicted by the unpublished bone data and the associated conclusions.

With respect to hunting and fishing the Alvastra region seems to have offered potentially very good resources. The environmental evidence certainly does not suggest that the people had to undertake long, extended and demanding expeditions to find the game. By studying the animal species identified (Chapter 7) as well as the vegetational history of the area around the pile dwelling (Göransson 1986), it is here argued that the identified food and fur animals probably existed within the resource area of the site because it provided an ideal ecosystem. Furthermore, it is likely that other wild species, the red fox and burbot for instance, could have existed in the area even if they are not identified in the material. Also, it is a fact that even today, when man has so much influenced the Alvastra province, many of the wild species noted archaeologically, both mammals, fishes and birds, are still present in the region.

There are remains of numerous different fur animals in the bone material from the site. This shows the importance of these animals to man as a valuable skin and fur resource, both for warmth and hardwearing clothing as well as perhaps as an attractive merchandise for exchange purposes (for example of flint and amber which were not to be found locally but are found among the artefact material from the pile dwelling). Usually in archaeozoological studies, animals such as the brown bear, badger and beaver are considered to have value as food, as well as for their pelts. However, the badger's fat might have been a further reason for killing

this species (Section 7.1.10) and this has not so far been sufficiently considered when interpreting faunal remains from prehistoric times. Badger fat could have been as important as its meat, especially for prehistoric groups who needed to take care of skin and leather articles. Badger fat seems to be one of the most suitable substances to use as a lubricant and preservative in this respect.

Marks from the skinning and butchering processes and marrow extraction reflect activities in connection with the human handling of bones. So also do the many find of bones manufactured into implements and ornaments. There are also gnaw marks of non-human teeth on the fragments, indicating that the bones were chewed by dogs after meals or simply gnawed by dogs and other species at times when the site was deserted by man. No distinct marks of human teeth have been noted. Such taphonomic factors as butchering and gnawing may have contributed to the heterogeneous distribution and loss of bone elements.

According to the measurements and comparative studies, all cattle remains seem to have belonged to domestic animals. No specimen is positively identified as aurochs. That herds of aurochs were still living in the area does not in fact seem likely. The ecosystem was probably far less suitable after Mesolithic times because of biotope changes. Possibly, however, single individuals of aurochs still wandered into the area (Section 7.1.1). In this connection it should also be noted that no specimen of European bison *(Bison bonasus)* has been positively identified in the material. Compared with the aurochs the fossil finds of European bison in Sweden are very few (Ekman 1922, p 386–387, 421). The aurochs and the European bison seem to have preferred different biotopes (Lepiksaar 1977, p 88–89). In view of the range of withers heights the Alvastra cattle seem to have belonged to a tall variety. This seems to be in agreement with Neolithic cattle stocks from other European sites.

There is no doubt that some of the pig remains come from wild boars, as indicated by measurements and calculations of withers heights showing the presence of animals of more than one meter in height. In addition, there are strongly developed male tusks in the material which has been manufactured into 'bone' objects. The inference that some remains represent the wild boar is supported by information from other bone samples from the site and by Ekman's (1974) data concerning measurements of the third lower molar. On the other hand, there also seems to be remains of smaller pigs. It is thus suggested that these remains may come from a stock of local wild boars which have, to some extent, been domesticated. The social behaviour, the variable food choice and other habits of the wild boar, speak in favour of local attempts to domesticate these animals. It is hard to see a need to import already domesticated pigs when a domestication of local wild piglets would not have been an impossible task. In Sweden since Mesolithic times, the wild boar has been an important fat and protein resource, and its value could have increased in the Neolithic. Pig domestication must have constituted a great challenge to man. Hunting and killing the dangerous wild boar probably also gave prestige and social status. In addition, it also provided the hunter the possibility to bring back a piglet as a pet animal for the children. This might have been a natural thing to do for the Early

Neolithic farmer and thus contributed to a domestication process. A continuing influence by the wild boar stock may have been the intermingling during rutting periods. This could have introduced different genes from the wild population, thus preventing extreme inbreeding. Moreover, it would probably have delayed the development of well defined domestication traits, such as shortening of the facial skeleton and the jaws and decrease in tooth size. Finally, the fact that all bone remains emanate from such a short time period (about 50 years) indicates that the remains of really large as well as smaller adult individuals come from the same time period. This emphasizes the possibility that wild and early domestic pigs lived in the area *at the same time.*

Thus, by studying the bone material from the pile dwelling, we get a 'snapshot' of a Middle Neolithic fauna and its exploitation by a human community some 5000 years ago. This detailed close-up shows a people who were well supplied with animal protein and no doubt vegetable food also. They probably formed a farming community with special interest in cattle-raising. The localities nearby provided them with good fishing waters such as Lake Tåkern, Lake Vättern and the Disevid stream; also rich hunting areas such as the surrounding lowland with large deciduous and also mixed forests, the mount Omberg and further away the woodland Holaveden. They surely knew how to exploit to the full these resources of nature, as well as cultivating the land.

It is still questionable what kind of habitation the pile dwelling was and whether it was permanently used throughout the year. Considering the most probable time periods when the juvenile pigs were killed and the most 'productive' slaughtering, hunting and fishing periods for the species present, people seem to have gathered for various activities at the site most frequently from early spring to late fall. There may have been peaks in late spring/early summer and the autumn. Among the bird remains the migrant species are predominant, a fact which supports this conclusion. Nevertheless, the finds of in particular various fur animals and also whitefish indicate certain activities at the site during the winter season. The evaluation of the bone material seems to show that such activities may have been more occasional than the ones in the summer season.

References

Aaris-Sørensen, K. 1978: Knoglematerialet fra den mellemneolitiske boplads ved Korsnäs, Grödinge socken, Södermanland. En zoologisk gennemgang. In: *Riksantikvarieämbetets forskningsnämnds serie forskning och utveckling,* 1–28. Stockholm.

Aaris-Sørensen, K. 1980: Atlantic fish, reptile and bird remains from the Mesolithic settlement at Vedbaek, North Zealand. *Vidensk. Medd. fra Dansk Naturhist. Foren. 142,* 139–149.

Aaris-Sørensen, K. 1981: A classification code and computerized data-analysis for faunal materials from archaeological sites. *OSSA 8,* 3–19.

Ahlén, I. 1965: Studies on the red deer, *Cervus elaphus* L., in Scandinavia. *Viltrevy. Swedish Wildlife, 3* (1–3).

Ahnlund. H. 1976: Age determination in the European badger, *Meles meles* L. *Z. F. Säugetierkunde 41,* 119–125.

Andersson, K. A. 1964: *Fiskar and Fiske i Norden* II. 2 uppl. Natur och Kultur, Stockholm.

Armitage, P. L. & Clutton-Brock. J. 1976: A system for classification and description of the horn cores of cattle from archaeological sites. *Journ. of Arch. Science 3,* 329–348.

Armitage, P. L. 1982: A system for ageing and sexing the horn cores of cattle from British post-medieval sites (17th to early 18th century) with special reference to unimproved British longhorn cattle. In Wilson, B., Grigson, C. & Payne, S. (eds.): *Ageing and Sexing Animal Bones from Archaeological Sites. BAR British Series 109,* 37–54. Oxford.

Arvidson, B. 1983: *Den Nordsvenska Allmogejakten.* Allmogejägaren, fångsten och försörjningen 1920–1940. ETNOLORE 1. Dept. of Ethnology. Univ. of Uppsala.

Baker, J. & Brothwell, D.R. 1980: *Animal Diseases in Archaeology.* Academic Press, London, New York, Toronto, Sydney and San Francisco.

Bartholin, Th. S. 1978: Alvastra pile dwelling: Tree studies. The dating and the landscape. *Fornvännen 73,* 213–219.

Becker, C. 1980: Untersuchungen an Skelettresten von Haus- und Wildschweinen aus Haithabu. *Berichte über die Ausgrabungen in Haithabu. Bericht 15.* Karl Wachholtz Verlag, Neumünster.

Beckman, B. 1954: Mats Kättilmundsson och hans tid, II 1319–1326. *Kungl. Vitt. Hist. och Antikv. Akademiens Handlingar, Del 85.* Stockholm.

Behrensmeyer, A.K. 1975: The taphonomy and paleoecology of Plio-Pleistocene vertebrate assemblages east of Lake Rudolf, Kenya. *Bull. of the Museum of Comparative Zoology 146* (10), 473–578.

Behrensmeyer, A.K. 1978: Taphonomic and ecologic information from bone weathering, *Paleobiology 4,* 150–162.

Bengtsson, T. & Hargeby, A. 1978: *Fiskeundersökningar i Tåkern 1977–78.* Tillväxt och ålderssammansättning hos mört, sarv, sutare, ruda och abborre. Unpubl. 10 points report. Dept. of Biology. Univ. of Linköping.

Bergius, B. 1787: *Tal om Läckerheter, både i sig sjelfva och sådana, och för sådana ansedda genom Folkslags bruk och inbillning,* hållet för Kongl. Vetenskaps Academien vid Praesidii nedläggande, den 3 maj 1780. Andra delen. J.G. Lange, Stockholm.

Berglund, B.E. 1968: Vegetationsutvecklingen i Norden efter istiden. In: *Sveriges Natur, Årsbok 1968,* 31–52. Svenska Naturskyddsföreningen.

Binford, L.R. & Bertram, J.B. 1977: Bone frequencies – and attritional processes. In L. Binford (ed): *For theory building in archaeology, 77–153. Academic Press. New York.*

Binford, L.R. 1978: *Nunamuit ethnoarchaeology.* Academic Press. New York.

Binford, L.R. 1981: *BONES. Ancient men and modern myths.* Academic Press. New York.

Boessneck, J., von den Driesch, A., Meyer-Lemppenau, U. & Wechsler- von Ohlen, E. 1971: Die Tierknochenfunde aus dem Oppidum von Manching. *Die Ausgrabungen in Manching. 6.* Franz Steiner, Wiesbaden.

Boessneck. J. 1973: *Arkeo-Osteologiska övningar.* Translation to Swedish by Prof. N.-G. Gejvall, Osteological Research Laboratory. Univ. of Stockholm.

Boessneck. J., von den Driesch, A. & Stenberger, L. (eds.) 1979: *Eketorp. Befestigung und Siedlung auf Öland/Schweden.* In: *Die Fauna.* Almqvist & Wiksell International, Stockholm.

Bohlken, H. 1961: Haustiere und Zoologische Systematik. *Z. Tierzücht. u. Züchtungsbiol. 76,* 107–113.

Bonnichsen, R. 1973: Some operational aspects of human and animal bone alteration. In Gilbert, M. (ed): *Mammalian Osteo-Archaeology: North America, 9–24.* University of Missouri-Columbia, Missouri.

Bosold. K. 1967: Geschlechts- und Gattungsunterschiede an Metapodien und Phalangen mitteleuropäischer Wildwiederkäuer. *Säugetierkundliche Mitteilungen 16,* 93–153.

Brink. F.H. van den, 1968: *Alla Europas däggdjur väster om 30° östlig längd.* Albert Bonniers förlag, Stockholm.
Brothwell, D.R. 1976: Further evidence of bone chewing by ungulates: The sheep of North Ronaldssay, Orkney. *Jorn. of Arch. Science 3,* 179–182.
Bruun, B. & Singer, A. 1975: *Alla Europas fåglar i färg.* En fälthandbok. Albert Bonniers förlag, Stockholm.
Brusewitz, G. 1978: *Jakt. Jägare, villebråd, vapen och jaktmetoder från äldsta tid till våra dagar.* Wahlström & Widstrand, Italy.
Brännäng, E. 1971: Studies on Monozygous Cattle Twins XXIII. The effect of castration and age of castration on the development of single muscles, bones and special sex characters. Part II. *Swedish Journ. of Agric. Research I,* 69–78.
Bull, G. & Payne, S. 1982: Tooth eruption and epiphyseal fusion in pigs and wild boar. In Wilson, B., Grigson, C. & Payne, S. (eds.): *Ageing and Sexing Animal Bones from Archaeological Sites. BAR British Series 109,* 55–71. Oxford.
Bökönyi, S. 1974: *History of Domestic Mammals in Central and Eastern Europe.* Akadémiai Kiadó, Budapest.
Casteel, R.W. 1977: A consideration of the behaviour of the minimum number of individuals index: A problem in faunal characterization, *OSSA 3/4,* 129–151.
Casteel, R.W. 1978: Faunal assemblages and the 'Wiegemethode' or Weight Method. *Journ. of Field Archaeology 5,* 71–77.
Chaplin, R.E. 1971: *The Study of Animal Bones from Archaeological Sites.* Seminar Press, New York & London.
Clason, A.T. 1967: Animal and Man in Holland's Past. *Paeleohistoria,* XIII. Groningen.
Clason, A.T. 1972: Some remarks on the use and presentation of archaeozoological data. *Helinium 12,* 139–153.
Clason, A.T. 1974: Archaeozoological research and the earliest stock-breeding in the Near East. *The Eastern Archaeologist 27,* 1–20.
Clason, A.T. & Prummel, W. 1977: Collecting, sieving and archaeozoological research. *Journ. of Arch. Science 4,* 171–175.
Clutton-Brock, J. 1981: *Domesticated animals from early times.* Brit. Mus. Nat. Hist., London.
Clutton-Brock, T.H., Guiness, F.E. & Albon, S.D. 1982: *Red deer. Behaviour and Ecology of Two Sexes.* Edinburgh Univ. Press, Edinburgh.
Cramp, S. & Simmons, K.E.L. 1977: *Handbook of the Birds of Europe the Middle East and North Africa. The Birds of the Western Palearctic.* I. Ostrich to Ducks. Oxford University Press, Oxford.
Cramp, S. & Simmons, K.E.L. 1980: *Handbook of the Birds of Europe the Middle East and North Africa. The Birds of the Western Palearctic.* II. Hawks to Bustards. Oxford University Press, Oxford.
Cramp, S. & Simons, K.E.L. 1983: *Handbook of the Birds of Europe the Middle East and North Africa. The Birds of the Western Palearctic.* III. Waders to Gulls. Oxford University Press, Oxford.
Degerbøl, M. 1933: Danmarks pattedyr i fortiden i sammenligning med recente former. I. (English summary: The Prehistoric Mammals of Denmark Compared with Recent Forms, 616–641.) *Vidensk. Medd. fra Dansk Naturhist. Foren. 96,* 2.
Degerbøl, M. 1939: IV. Dyreknogler. In Mathiassen, Th., Jessen, K. & Degerbøl, M.: Bundsø, en yngre Stenalders Boplads paa Als. *Aarb. for nordisk Oldkyndighed og Historie,* 85–198.
Degerbøl, M. 1943: Om Dyrelivet i Aamosen i Stenalderen. In Mathiassen, Th.: *Stenalderbopladser i Aamosen.* Nordiske Fortidsminder III, 165–206. Nordisk forlag, København.
Degerbøl, M. 1963: Prehistoric Cattle in Denmark and Adjacent Areas. In Mourant, A.E. & Zeuner, F.E. (eds.): *Man and Cattle. Royal Anthrop. Inst. Occasional Paper 18,* 69–79. London.
Degerbøl, M. & Fredskild, B. 1970: The Urus *(Bos primigenius bojanus)* and Neolithic Domesticated Cattle *(Bos taurus domesticus* Linné) in Denmark. *Det Kongl. Danske Videnskabernes Selskab Biologiske Skrifter 17,* 1.
Driesch, A. von den & Boessneck, J. 1975: Schnittspuren an neolitischen Tierknochen. Ein Beitrag zur Schlachttierzerlegung in vorgeschichtlicher Zeit. *Germania 53,* 1–23.
Driesch, A. von den 1976: *A Guide to the Measurement of Animal Bones from Archaeological Sites.* Peabody Museum Bull. I. Peabody Mus. of Archaeology and Ethnology, Harvard University.
Ducos, P. 1984: La contribution de l'archaeozoologie à l'estimation des quantités de nourriture. Evaluation du nombre d'individues. In Clutton-Brock, J. & Grigson, C. (eds.): *Animals in Archaeology 3. Early Herders and their Flocks. BAR International Series 202,* 13–23.
Duerst, J.U. 1904: Die Tierwelt der Ansiedelungen am Schlossberge zu Burg and der Spree. *Archiv f. Anthrop. N.F. II,* Braunschweig.

Duerst, J.U. 1926: Vergleichende Untersuchungsmethoden am Skelett bei Säugern. In *Handbuch der biologischen Arbeitsmethoden, Abt. 7:* Methoden der vergleichenden morphologischen Forschung, Heft 2, 125–530. Berlin & Wien.
During, E. 1983: Stenålder eller Medeltid i Alvastra? Inlägg i en 60-årig diskussion. *Fornvännen 78,* 176–188.
During, E. 1985: On relative quantification of faunal remains from archaeological sites. *ISKOS 5,* 227–231.
Efremov, I.A. 1940: Taphonomy, a new branch of paleoontology. *Pan-Amer. Geol. 74,* 81–93.
Ellenberger, W., Baum, H. & Dittrich, H. 1956: *An Atlas of Animal Anatomy for Artists.* Dover Publications, Inc., New York.
Elton, Ch. 1942: *Voles, mice and lemmings.* The Clarendon Press, London. (reprint: 1965).
Ekman, J. 1972: The Urus female *(Bos primigenius Boj.)* from Slågarp, Southern Sweden. *Zoologica Scripta 1,* 203–205.
Ekman, J. 1973: *Early Mediaeval Lund – the fauna and the landscape.* An osteological investigation of bone remains from the early mediaeval settlement. Archaeologica Lundensia V. Berlingska Boktryckeriet, Lund.
Ekman, J. 1974: Djurbensmaterialet från stenålderslokalen Ire, Hangvar sn., Gotland. In Janzon, G.O.: *Gotlands mellanneolitiska gravar. Acta Universitatis Stockholmiensis,* 212–246. Almqvist & Wiksell, Stockholm.
Ekman, J. 1977: List of animal bone material from the Alvastra pile dwelling. Unpublished manuscript.
Ekman, J. & Iregren E. 1984: *Early Norrland 8.* Archaeo-Zoological Investigations in Northern Sweden. Almqvist & Wiksell International, Stockholm.
Ekman, S. 1910: *Norrlands jakt och fiske.* Norrländskt Handbibliotek IV. Almqvist & Wiksell, Uppsala.
Ekman, S. 1922: *Djurvärldens Utbredningshistoria på Skandinaviska halvön.* Albert Bonniers Förlag, Stockholm.
Ekstam, U. 1975: Förändringar av fågelfauna och miljö i och vid Tåkern 1850–1974. *Vår Fågelvärld 34* (4), 268–282.
Endt, D.W. von & Ortner, P.J. 1984: Experimental effects of bone size and temperature on bone diagenesis. *Journ. of Arch. Science 3,* 247–253.
Englund, J. 1970: Some aspects of reproduction and mortality rates in Swedish foxes *(Vulpes vulpes),* 1961–63 and 1966–69. *Viltrevy. Swedish Wildlife 8,* 1–82.
Englund, J. 1980: Population dynamics of the red fox *(Vulpes vulpes* L., 1758) in Sweden. In Zimen, E. (ed): *Biogeographica, 18: The Red Fox,* 107–121. Dr W. Junk bv Publishers, the Hague.
Essen, L. von 1958: Rådjuret. In Hamilton, H. (ed): *Svenska hjortdjur,* 567–648. Bokförlaget Gothia AB, Stockholm.
Fieller, N.R.J. & Turner, A. 1982: Number estimations in vertebrate samples. *Journ. of Arch. Science 9,* 49–62.
Figdor, H. 1927: Über den Einfluss der Kastration auf das Knochen-Wachstum des Hausrindes. *Z. Tierzücht. u. Züchtungsbiol. 9,* 101–112.
Fock, J. 1966: *Metrische Untersuchungen an Metapodien einiger europäischer Rinderrassen.* Diss. München.
Frödin, O. 1910a: En svensk pålbyggnad från stenåldern. *Fornvännen,* 29–77.
Frödin, O. 1910b: Ein schwedisher Phalbau aus der Steinzeit. *Mannus 2,* 109–152.
Gabriel, P. 1934: Kopfdarm und Schlund des Wildschweines (excl. Mundboden). *Z. Anat. Entwicklungsgeschichte 102,* 521–571. 16 Abb.
Gardell, T. 1958: Älgen. In Hamilton, H. (ed.): *Svenska hjortdjur,* 101–204. Bokförlaget Gothia AB, Stockholm.
Gejvall, N.-G. 1963: Cremations. In Brothwell, D.R., Higgs, E. (eds.): *Science in Archaeology,* 468–479. Thames & Hudson, London.
Gejvall, N.-G. 1969: *Lerna a preclassical site in the Argolid, 1. The Fauna.* Amer. School of Class. Stud. Publ., Princeton New York.
Gejvall, N.-G. 1981: Eketorp – Die Fauna. *Kungl. Vitt. Hist. och Antikvitets Akademiens Årsbok,* 113–119.
Gilbert, A.S., Singer, B.H. & Perkins, D. Jr. 1981: Quantification experiments on computer – simulated faunal collections. *OSSA 8,* 79–94.
Gilbert, A.S. & Singer, B.H. 1982: Reassessing zooarchaeological quantification. *World Archaeology 14,* 21–40.

Grant, A. 1978: Variation in dental attrition in mammals and its relevance to age determination. In Brothwell. D.R., Thomas, K.D. & Clutton-Brock, J., (eds.): *Research Problems in Zooarchaeology. Inst. of Archaeology. Occasional Publ. No. 3,* 103–106. London.

Grayson, D.K. 1973: On the methodology of faunal analysis. *Amer. Antiquity 38,* 432–439.

Grayson, D.K. 1978: Minimum numbers and sample size in vertebrate faunal analysis. *Amer. Antiquity 43,* 54–65.

Grayson, D.K. 1979: On the quantification of vertebrate archaeofaunas. In Schiffer, M.B.: *Advances in Archaeological Method and Theory 2,* 199–237. Academic Press, New York.

Grigson, C. 1982a: Sex and age determination of some bones and teeth of domestic cattle: a review of the literature. In Wilson, B., Grigson, C. & Payne, S. (eds.): *Ageing and Sexing Animal Bones from Archaeological Sites. BAR British Series 109,* 7–23. Oxford.

Grigson, C. 1982b: Sexing Neolithic domestic cattle skulls and horn cores. In Wilson, B., Grigson, C. & Payne, S. (eds.): *Ageing and Sexing Animal Bones from Archaeological Sites. BAR British Series 109,* 25–73. Oxford.

Guthrie, R.D. 1983: Osseous Projectile Points: Biological considerations affecting raw material selection and design among Paleoindian peoples. In Clutton-Brock. J. & Grigson, C. (eds.): *Animals in Archaeology 1. Hunters and their Prey. BAR International Series 163.* Oxford.

Gyttorps Jakttidtabell 1/1 1983 – 31/12 1985. Husqvarna Vapen. Svenska Jägareförbundet, Stockholm.

Göransson, H. 1982a: The utilization of the forests in North – West Europe during Early and Middle Neolithic. *PACT 7,* 207–221.

Göransson, H. 1982b: Neolitikums begynnelse i Östergötland, Sverige, enligt pollenanalytiska data. In Sjøvold, Th. (ed.): *Introduksjonen av jordbruk i Norden. Det Norske Videnskaps-Akademi,* 99–123. Universitetsforlaget, Oslo, Bergen and Tromsø.

Göransson, H. 1986: Neolithic man and the forest environment around Alvastra Pile Dwelling (in press):

Habermehl, K-H. 1961: *Die Altersbestimmung bei Haustieren, Pelztieren und beim jagdbaren Wild.* Verlag P. Parey, Berlin & Hamburg.

Hallström, A. 1979: Die Fischknochen. In Boessneck, J., von den Driesch, A. & Stenberger, L. (eds.): *Eketorp. Befestigung und Siedlung auf Öland/Schweden.* In: *Die Fauna.* Almqvist & Wiksell International, Stockholm.

Hammond, J., Mason, I.L. & Robinson, T.J. 1971: *Hammond's farm animals.* Edward Arnold, London.

Harder, W. 1975: *Anatomy of Fishes.* Schweizerbart, Stuttgart.

Hargeby, A. 1985: Från stenålderns malar till rudor i överflöd. *Vingspegeln 4* (2), 92–96.

Hatting, T. 1969: Age determination for subfossil beavers (*Castor fiber* L.,) (Mammalia) on the basis of radiographs of teeth. *Vidensk. Medd. fra Dansk Naturhist. Foren. 132,* 115–128.

Hatting, T. 1978: Lidsø. Zoological remains from a Neolithic settlement. In Davidsen, K.: *The Final TRB Culture in Denmark. A settlement study. Arkeologiske Studier V.* Akademisk Forlag, Copenhagen.

Haynes, G. 1980a: Evidence of carnivore gnawing on Pleistocene and recent mammalian bones. *Paleobiology 6* (3), 341–351.

Haynes, G. 1980b: Prey bones and predators: Potential ecologic information from analysis of bone sites. *OSSA 7,* 75–97.

Haynes, G. 1981: *Bone Modification and Skeletal Disturbances by Natural Agencies: Studies in North America.* Ph.D. diss. Departm. of Anthrop., Catholic Univ. of America, Wash. D.C. University Microfilms International Ann Arbor, Michigan.

Haynes, G. 1983a: A guide for differentiating mammalian carnivore taxa responsible for gnaw damage to herbivore limb bones. *Paleobiology 9,* 164–172.

Haynes, G. 1983b: Frequencies of spiral and green-bone fractures on ungulate limb bones in modern surface assemblages. *Amer. Antiquity 48* (1), 102–114.

Haynes, G. 1983c: Book review of BONES: Ancient men and modern myths, by L. Binford. *North Amer. Archaeologist 4* (3), 245–254.

Haynes, G. 1984: Taphonomic perspectives on late Pleistocene extinctions: Fieldwork projects. *Taphonomy Current Research 1,* 49–50.

Hedell, L. 1909–1913, 1919: Analyses of bone materials from excavations of the Alvastra Pile Dwelling. Unpublished manuscripts.

Hedell, L. 1910: Fiskbenen i Alvastrafyndet. *Fornvännen,* 64.

Higham, C. & Message, M. 1969: An assessment of a prehistoric technique of bovine husbandry. In Brothwell, D.R. & Higgs, E. (eds.): *Science in Archaeology.* 2nd ed., 315–330. Thames & Hudson, London.

Hill, A.P. 1976: On carnivore and weathering damage to bone. *Current Anthropology 17* (3), 335–336.
Hill, A.P. 1979: Butchery and natural disarticulation: An investigation technique. *Amer. Antiquity 44* (4), 739–744.
Horton. D.R. 1984: Minimum numbers: a consideration. *Journ. of Arch. Science 2,* 255–271.
Iregren, E. 1975: Age-dependent changes in the lower extremities of the elk *(Alces alces)* in Central Sweden. In Clason, A.T. (ed.): *Archaeozoological Studies. Papers of the Archaeozoological Conference 1974, in Groningen,* 367–380. North-Holland Publ. Comp., Amsterdam, Oxford & Amer. Elsevier Publ. Comp., Inc., New York.
Jonsson, S. 1983: *Lodjur.* Natur och Kultur, Stockholm.
Keith, L.B. 1963: *Wildlife's Ten-year Cycle.* University of Wisconsin Press, Madison.
Kinberg, J.C.H. 1869: *Undersökningar rörande djurens historia.* I. Ossa metacarpi et metatarsi *Ovis* et *Caprae.* 10 mars 1868. Öfvers. Kungl. Vetensk. Akademiens Förlag, 359–433. Stockholm.
Krantz, G.S. 1968: A new method of counting mammal bones. *Amer. Journ. of Archaeology 72,* (3), 286–288.
Kurtén, B. 1959: Rates of evolution in fossil mammals. Cold Spring Harbor Symposium. *Quant. Biol. 24,* 205–215.
Kurtén, B. 1965a: The carnivora of the Palestine caves. *Acta Zool. Fennica 107,* 1–74.
Kurtén, B. 1965b: On the evolution of the European wild cat, *Felis silvestris* Schreber. *Acta Zool. Fennica 111,* 2–29.
Kwam, T. 1979: Reproduksjonsforhold og populasjonsstruktur hos gaupe, *(Lynx lynx* L.). Upubl. hovedsfagsoppgave i spesiel zoologi til Matematisk-Naturvitenskapelig embedseksamen ved Univ. i Trondheim.
Larsson, L. 1978: *Ageröd I:B – Ageröd I:D.* A Study of Early Atlantic Settlement in Scania. *Acta Archaeologica Lundensia Ser. in 4°, N° 12.* Rudolf Habelt Verlag, Bonn & CWK Gleerups Förlag, Lund.
Larsson, L. 1980: Stenåldersjägarnas boplats och gravar vid Skateholm. *Limhamniana 1980.* Malmö.
Larsson, L. 1981: En 7000-årig sydkustboplats. Nytt om gammalt från Skateholm. *Limhamniana 1981.* Malmö.
Larsson, L. 1982: Skateholmsprojektet. Nya gravar och ett nytt gravfält. *Limhamniana 1982.* Malmö.
Larsson, L. 1983a: Skateholmsprojektet. Jägare – Fiskare – Bönder. *Limhamniana 1983.* Malmö.
Larsson, L. 1983b: *Ageröd V.* An Atlantic Bog Site in Central Scania. *Acta Archaeologica Lundensia Ser. in 8°, N° 12.* Bloms Boktryckeri AB, Lund.
Larsson, L. 1984: Skateholmsprojektet. På spåren efter gravsedsförändringar, ceremoniplatser och tama rävar. *Limhamniana 1984.* Malmö.
Lavsund, S. 1975: *Bävern i Sverige.* Statens Naturvårdsverk. Liber Förlag/Allmänna Förlaget, Stockholm.
Lawrence, D.L. 1968: Taphonomy and information losses in fossil communities. *Geological Soc. of America Bull. 79,* 1315–1330.
Lawrence, D.L. 1971: The nature and structure of paleoecology. *Journ. of Paleontology 45* (4), 593–607.
Lekholm, C.G. 1951: A technical study of some Scanian bone fish-hooks. *Medd. från Lunds Univ. Hist. Mus., K. Hum. Vetenskapssamf. i Lund Årsberättelse 1950–1951, IV,* 245–265. Lund.
Lepiksaar, J. 1963: Husdjurens historia i Skåneland. *ALE 2,* 25–39.
Lepiksaar, J. 1969: X. Knochenfunde aus den Bronzezeitlichen Siedlungen von Hötofta. In Stjernquist, B.: *Beiträge zum Studium von Bronzezeitlichen Siedlungen. Acta Archaeologica Lundensia Ser. in 8°. N° 8.* Rudolf Habelt Verlag, Bonn & CWK Gleerups Förlag, Lund.
Lepiksaar, J. 1973: Die vorgeschichtlichen Haustiere Schwedens. In Matolsci, J. (ed.): *Domestikationsforschung und Geschichte der Haustiere. Internationales Symposion in Budapest 1971.* Akadémiai Kiadó, Budapest.
Lepiksaar, J. 1974: Djurrester från den mellanneolitiska (gropkeramiska) boplatsen vid Äs, Romfartuna sn., Västmanland. In Löfstrand, L.: *Yngre stenålderns kustboplatser. Aun 1,* Uppsala.
Lepiksaar, J., Heinrich, D. & Radtke, Ch. 1977a: Untersuchungen an Fischresten aus der frühmittelalterlischen Siedlung Haithabu. *Berichte über die Ausgrabungen in Haithabu. Bericht 10.* Karl Wachholtz Verlag, Neumünster.
Lepiksaar, J. 1977b: Människan och husdjuren. *Fauna och Flora 2/3,* 79–101.

Lepiksaar, J. 1978: Bone remains from the Mesolithic settlements Ageröd I:B and Ageröd I:D. In Larsson, L.: *Ageröd I:B – Ageröd I:D.* A Study of Early Atlantic Settlement i Scania. *Acta Archaeologica Lundensia Ser. in 4°. N° 12.* Rudolf Habelt Verlag, Bonn & CWK Gleerups Förlag, Lund.

Lepiksaar, J. 1982: Djurrester från den tidigatlantiska boplatsen vid Segebro nära Malmö i Skåne (Sydsverige). In Larsson, L.: *Segebro en tidigatlantisk boplats vid Segeås mynning. Malmöfynd 4.* Malmö.

Lepiksaar, J. 1983a: Animal remains from the Mesolithic bog site at Ageröd V in Central Scania. In Larsson, L.: *Ageröd V.* An Atlantic Bog Site in Central Scania. *Acta Archaeologica Lundensia Ser. in 8°. N° 12.* Bloms Boktryckeri AB, Lund.

Lepiksaar, J. 1983b: Zoologisk undersökning. In Wigforss, J., Lepiksaar, J., Olsson I.U. & Påsse T.: *Bua Västergård – en 8000 år gammal kustboplats. Arkeologi i Västsverige 1.* Göteborgs Arkeologiska Museum.

Lesbre, F.-X. 1897/98: Contribution à l'étude de l'ossification du squelette des mammifères domestiques. *Annales de la Societé d'Agriculture, Sciences et Industrie de Lyon Sér. 7, 5,* 1–106.

Lie, R.W. 1980: Minimum number of individuals from osteological samples. *Norw. Arch. Rev. 13* (1), 24–30.

Lie, R.W. 1983: Reply. *Norw. Arch. Rev. 16* (1), 49.

Lieberkind, I. 1937a: *Djurens Värld.* En populärvetenskaplig framställning av djurens liv på grundval av Brehm's Tierleben. *Däggdjur III:12.* Wallengren, H. (ed.) Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1937b: *Djurens Värld. Fåglar 1:7.* Wallengren, H. (ed.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1938: *Djurens Värld. Fåglar III:9.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1939a: *Djurens Värld. Däggdjur II:11.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1939b: *Djurens Värld. Fiskar I:4.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1939c: *Djurens Värld. Fiskar II:5.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1940a: *Djurens Värld. Däggdjur I:10.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Lieberkind, I. 1940b: *Djurens Värld. Fåglar II:8.* Wallengren, H. & Hanström, B. (eds.). Svensk Uppslagsbok A.-B., Malmö.

Liljegren, R. 1975: Subfossila Vertebratfynd från Skåne. Univ. of Lund, Dept. of Quaerternary. *Geological report 8,* Lund.

Liljegren, R. 1983: Uroxen i lundatrakten – ett sagodjur redan under yngre stenålder. *Skånes Natur. Skånes Naturvårdsförbunds Årsskrift 70,* 29–36.

Lloyd, L. 1855: *Anteckningar under Ett Tjuguårigt Vistande i Skandinavien.* Innehållande Jagtäfventyr, Råd för Jägare och Fiskare, samt strödda bidrag till Nordens Fauna. (Öfversättn. fr. Eng.). Sednare Delen. Albert Bonniers förlag, Stockholm.

Lundberg, C. 1958: Rådjurets levnadsvanor och näringsförhållanden. In Hamilton, H. (ed.): *Svenska hjortdjur II,* 649–678. Bokförlaget Gothia AB, Stockholm.

Lyman, R.L. 1979: Available meat from faunal remains: a consideration of techniques. *Amer. Antiquity 44* (3), 536–546.

Magnusson, E. 1964: Pollenanalytical investigations at *Tåkern, Dags mosse* and the Neolithic settlement at Alvastra, Sweden. *Sveriges Geol. Undersökn. Ser. C Nr 597. Årsbok 58 Nr 3.* Stockholm.

Malmer, M.P. 1962: *Jungneolithische Studien.* Acta Archaeologica Lundensia Ser. in 8°. N° 2. Rudolf Habelt Verlag, Bonn & CWK Gleerups Förlag, Lund.

Malmer, M.P. 1978: Forskningsprojektet Alvastra pålbyggnad. *Fornvännen 73(3),* 149–158.

Malmer, M.P. 1981: The explanation of a pile dwelling. *Striae 14,* 26–28. Uppsala.

Malmer, M.P. 1983a: Alvastra pålbyggnads konstruktion och användning. In Olafsson, G. (ed.): *Hus, Gård och Bebyggelse. Föredrag från det XVI nordiska arkeologmötet, Island 1982.* Reykjavik.

Malmer, M.P. & Bartholin, Th.S. 1983b: Alvastra paelebygning. *Skalk 4,* 18–22.

Malmer, M.P. 1984: On the social function of pile dwellings and megaliths. In Burenhult, G. (ed.): *The Archaeology of Carrowmore. Theses and Papers in North European Archaeology 14,* 371–375. Stockholm.

Maltby, J.M. 1982: The variability of faunal samples and their effects upon ageing data. In Wilson, B., Grigson, C. & Payne, S. (eds.): *Ageing and Sexing Animal bones from Archaeological Sites. BAR British Series 109,* 81–90. Oxford.

Maschke, G.H. 1967: Ageing European wild hogs by dentition. *Journ. of Wildlife Management 31,* 109–113.

Matolcsi, J. 1970/71: Historische Erforschung der Körpergrösse des Rindes auf Grund von ungarischem Knochenmaterial. *Z. Tierzüht, u. Züchtungsbiologie 87,* 89–137.

Mech, D. 1970: *The Wolf: the ecology and behaviour of an endangered species.* The Amer. Mus. of Nat. Hist. The Natural History Press. Garden City, New York.

Mohr, E. 1960: *Wilde Schweine.* Die Neue Brehm – Bücherei. A. Ziemsen Verlag, Wittenberg Lutherstadt.

Muus, B.J. & Dahlström, P. 1981: *Sötvattensfisk och fiske.* P.A. Norstedt & Söners Förlag, Stockholm.

Myers, T.P., Voorhies, M.R. & Corner, R.G. 1980: Spiral fractures and bone pseudotools at paleontological sites. *Amer. Antiquity 45* (3), 483–490.

Møhl, U. 1957: Zoologisk gennemgang af knoglematerialet fra jernaldersbopladserne Dalshøj og Sorte Muld, Bornholm. In Klindt-Jensen, O.: *Bornholm i Folkevandringstiden og forudsætningerne i tidlig jernalder. Nationalmuseet Skrifter Større beretninger II.*

Møhl. U. 1962: Übersicht über Knochenfunde aus Gräbern der schwedisch-norwegischen Streitaxt-kultur. In Malmer, M.P.: *Jungneolithische Studien. Acta Archaeologica Lundensia Ser. in 8°. N° 2.* Rudolf Habelt Verlag, Bonn & CWK Gleerups Förlag, Lund.

Neal, E.G. 1977: *Badgers.* Blandford Mammal Series. Blandford Press, Poole, Dorset. England.

Nickel, R., Schummer, A. & Seiferle, E. 1961: *Lehrbuch der Anatomie der Haustiere.* Band I. Paul Parey, Berlin & Hamburg.

Nobis, G. 1954: Zur Kenntnis der ur- und frühgeschichtlichen Rinder Nord- und Mitteldeutschlands. *Z. Tierzüht. u. Züchtungsbiologie 63,* 155–194.

Noe-Nygaard, N. 1977: Butchering and marrow fracturing as a taphonomic factor in archaeological deposits. *Paleobiology 3,* 218–237.

Noodle, B. 1982: The size of red deer in Britain – past and present, with some reference to fallow deer. In Limbrey, S. & Bell, B. (eds.): *Archaeological Aspects of Woodland Ecology.* Symp. of the Ass. for Environmental Archaeology No. 2. *BAR International Series 146.* Oxford.

Odum. E.P. 1966: *Samspelet i Naturen.* Stockholm.

Paaver, K.L. 1965: *Die Entstehung der Säugetierfauna und die Variabilität der Säugetiere des Ostbaltikums im Holzän* (Orig. in Russia). Institut för Zoologi och Botanik. Vet. Ak. Est. S.S.R., Tartu.

Payne, S. 1975: Partial recovery and sample bias. In Clason, A. (ed.): *Archaeozoological Studies. Papers of the Archaeozoological Conference 1974, in Groningen,* 7–17. North-Holland Publ. Comp., Amsterdam and Amer. Elsevier Publ. Comp., Inc., New York.

Perkins, D. Jr. & Daly, P. 1968: A hunters' village in Neolithic Turkey. *Scientific American 219* (5), 97–106.

Perkins, D. Jr. 1973: A critique on the methods of quantifying faunal remains from archaeological sites. In Matolsci, J. (ed.): *Domestikationsforschung und Geschichte der Haustiere. Internationales Symposion in Budapest 1971,* 367–370, Akadémiai Kiadó, Budapest.

Petterson, M. & Olausson, E. 1952: Eine mesolitische Fischreuse aus Jonstorp, Schonen. *Medd. från Lunds Univ. Hist. Mus., K. Hum. Vetenskapssamf. i Lund Årsberättelse 1951–1952, VII,* 141–157. Lund.

Pira, A. 1909: Studien zur Geschichte der Schweinerassen, inbesondere derjenige Schwedens. *Zool. Jahrbüchern, Suppl. 10* (2), 233–246. Jena.

Pira, A. 1910: Berättelse om undersökning af benen i Alvastrafyndet. *Fornvännen 1910,* 62–64, and an unpublished manuscript.

Pira, A. 1926/27: On bone deposits in the cave *'Stora Förvar'* on the isle of *Stora Karlsö,* Schweden. (A contribution to the knowledge of prehistoric domestic animals.) *Acta Zoologica 7,* 123–217.

Poplin, F. 1978/79: Essai d'ostéologie quantitative sur l'estimation du nombre d'individus. In: *Kölner Jahrbuch für Vor- und Frühgeschichte 16,* 153–164. Festschrift Hermann Schwabedissen II. Gebr. Mann Verlag, Berlin.

Post, L. von 1916: Einige südschwedischen Quellmoore. *Bull. of the Geol. Inst. of the Univ. of Uppsala 15,* 219–278. Uppsala.

Reinwaldt, E. & Erkinaro, E. 1959: Zur Taxonomie und Verbreitung des Baummarders, *Martes martes* (Linné 1758). *Säugetierk. Mitt., 7* (3).

Sammons, K., Topinka, K. & Hamilton, S. 1981: Faunal material from the west end of zone F. In: *Papers in Manitoba Archaeology. Miscellaneous Paper No. 12.* 1979 Excavations at the Stott Site (DIM a-1): with interpretations of cultural stratigraphy, 92–128. Dept. of Cult. Affairs & Hist. Resources, Historic Resourch Branch. Brandon Univ., Canada.

Schmiterlöw, C.G. 1975: Veterinär medicinsk undervisning under 200 år. In: *Bot för Boskapssot. Svensk Veterinärmedicin 200 år,* 71–130. Jubileumskommittén för Svensk Veterinärmedicin 200 år. Skara.

Schnittger, B. 1910: Förhistoriska flintgrufvor och kulturlager vid Kvarnby och S. Sallerup i Skåne. *Antikvarisk Tidskrift* 19 (1).

Shipman, P. & Phillips, J.E. 1976: On scavenging by homonids and other carnivores. *Current Anthropology 17,* (1), 170–172.

Shipman, P. & Phillips-Conroy, J.E. 1977: Homonid tool-making versus carnivores' scavenging. *Amer. Journ. of Phys, Anthropology 46,* (1), 77–86.

Shipman, P. 1981: Applications of scanning electron microscopy to taphonomic problems. *Annals of the New York Academy of Sciences 376,* 357–386.

Siegel, J. 1973: Animal palaeopathology: possibilities and problems. *Journ. of Arch. Science 3,* 349–384.

Siivonen, L. 1976: *Nordeuropas däggdjur.* P.A. Norstedts & Söners Förlag, Stockholm.

Silver, I.A. 1969: The ageing of domestic animals. In Brothwell, D. & Higgs, E. (eds.): *Science in Archaeology. 2nd ed.,* 283–302. Thames & Hudson, London.

Sjøvold, T. 1976: Das Knochenmaterial von der Siedlung bei Björnhovda, Ksp., Torslunda, Öland. Exkurs III in Hagberg, U.E.: *Fundort und Fundgebiet der Modeln aus Torslunda. Frümittelalterliche Studien 10,* 323–349.

Sjøvold, T. 1986: A comparison between methods for estimating the withers height from skeletal measurements (in press).

Slakteriorganisationen (SCAN) i siffror 1982. Slakteriförbundet.

Spahn, N. 1978: Untersuchen an grossen Röhrenknochen von Schafen und Ziegen aus der frümittelalterlichen Siedlung Haithabu (800–1050). *Schriften aus der Archäologisch-Zoologischen Arbeitsgruppe Schleswig-Kiel, 3. Schlesw.-Holstein.* Landesmus. für Vor- und Frühgeschichte. Inst. für Haustierkunde der Univ. Kiel. Kiel.

Stampfli, H.R. 1976: *Osteo-archaeologische Untersuchung des Tierknochen materials der spätneolitischen Ufersiedlung Auvernier La Saunerie.* Solthurn (privately printed for Dr Stampfli).

Steck, F. & Vandeler, A. 1980: The epidemiology of fox rabies in Europe. *Epidemiological Reviews 2, 71–96.*

Stjernquist, B. Nilsson, T. & Nybelin, O. 1953: Some Stone Age fishing tackle from Scania. Medd. från Lunds Univ. Hist. Mus., K. Hum. Vetenskapssamf. i Lund Årsberättelse 1952–1953, IV, 123–148.

Stolpe, H. & Arne, T.J. 1912: *Graffältet vid Vendel.* KVHAA monografier. Stockholm.

Sutcliffe, A.J. 1973: Similarity of bones and antlers gnawed by deer to human artifacts. *Nature 246,* 428–430.

Teichert, M. 1969: Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei vor- und frühgeschichtlichen Schweinen. *Kühn – Archiv 83,* 237–292.

Teichert, M. 1975: Osteometrische Untersuchungen zur Berechnung der Widerristhöhe bei Schafen. In Clason, A. (ed.): *Archaeozoological Studies. Papers of the Archaeozoological Conference 1974, in Groningen,* 51–69. North-Holland Publ. Comp., Amsterdam, Oxford & Amer. Elsevier Publ. Comp., Inc., New York.

Trybom, F. 1893: Ringsjön i Malmöhus län. Dess naturförhållanden och fiske (med en karta). *Medd. från Kongl. Landtbruksstyrelsen 4* (13), 3–46. Stockholm.

Tyrberg, T. 1980: Artlista över Tåkerns fåglar. *Medd. Tåkerns Fältstation 16,* 26–34.

Uerpmann, H.-P. 1973: Ein Beitrag zur Methodik der Wirtschaftshistorischen Auswertung von Tierknochen aus Siedlungen. In Matolsci. J. (ed.): *Domestikationsforschung und Geschichte der Haustiere. Internationales Symposion in Budapest 1971,* 391–396. Akadémiai Kiadó, Budapest.

Valeur, P. 1977: Faktorer av betydning for fastsettning av jakttiden på bever (2.4). Pelsning av bever og skinbehandling (2.6.2). *Proceedings from the Nordic Symp. on the Beaver 1975, Ramsele, Sweden. Inst. of Forest Zoology. Research Notes 26,* 84–86, 95–100. Royal College of Forestry. Stockholm.

Wahlhovd, H. 1965: Aldersbestemmelse av hare *(Lepus timidus L.)* om alders- og kjønnsfordelning, vekst og vekt. *Medd. Fra Statens Viltundersøkelser 2* (22), 1–57.

Watson, J.P.N. 1978: The interpretation of epiphyseal fusion data. In Brothwell, D.R., Thomas, K.D. & Clutton-Brock, J. (eds.): *Research problems in Zooarchaeology. Inst. of Archaeology. Occasional Publ. No. 3,* 97–102. London.

Wendt, C. 1968: *Utredning av fiskefrågor av betydelse för Vätterns utnyttjande.* Bil. 2 Vätterns fiskarter. Göteborg.
Werdelin, L. 1981: The evolution of lynxes. *Ann. Zool. Fennici 18,* 37–71.
White, T.E. 1952: Observations on the butchering technique of some aboriginal peoples. *Amer. Antiquity 17* (4), 337–338.
White, T.E. 1953: A method of calculating the dietary percentage of various food animals utilized by aboriginal people. *Amer. Antiquity 18* (4), 396–398.
Wijngarden-Bakker, L., H. van 1980: *An Archaeozoological Study of the Beaker Settlement at New Grange,* Ireland. Ph. Dr. Diss. Amsterdam.
Wild, C.K. & Nichol, R.K. 1983: A note on Rolf Lie's approach to estimating minimum numbers from osteological samples. *Norw. Arch. Rev. 16* (1), 45–49.
Winge, H. 1900: Dyreknogler i affaldsdynger fra stenalderen i Danmark. In Madsén, A.P., Müller, S. et al.: *Affaldsdynger fra Stenalderen i Danmark undersøgte for Nationalmuseet,* 144–147, 158–163, 171–172. Paris. København. Leipzig.
Winge. H. 1903: Om jordfunne fugle fra Danmark. *Vidensk. Medd. fra Dansk Naturhist. Foren. 55.*
Winge, H. 1908: *Pattedyr. Danmarks Fauna.* Illustrerede Haandbøger over den Danske Dyreverden. G.E.C. Gad, Købehavn.
Winther, J. 1935: *Troldebjerg.* (Rudkøbing).
Winther, J. 1943: *Blandebjerg.* (Rudkøbing).
Zeuner, F.E. 1963: *A History of Domesticated Animals.* Hutchinson & Co. London.

APPENDIX

Statistical methods and approximations for distributing 'grouped material' among species

by Eva Elvers

In this appendix we will describe in greater detail both the statistical method and approximations that are used in Chapter 5. The number of fragments identified to a certain species a is called x. The unknown number of fragments within the 'grouped material' belonging to a is called y.

We assume that x and y are independent random variables, having binomial distributions and initially also that the probability parameters are equal. A simple estimate of y is

$$y^* = \frac{mx}{n}$$

where n and m are the numbers of fragments that are identified with regard to species and group respectively.

We would like to measure the uncertainty of the estimate y^*. Since y^* is random, we compute prediction limits for the point estimate. To do this, we test the hypothesis that the two probability parameters are equal. We use the y-values so that the hypothesis is not rejected on the level α as a prediction region for y, on the level $(1\text{-}\alpha)$. There are a number of applicable tests, and when we choose one we consider if an upper or lower prediction bound is relevant or an interval. The interpretation of these prediction regions is that, if we repeat the process of taking samples (of both x and y) with m and n fixed, the prediction region will be correct in 100 $(1\text{-}\alpha)$ % of the cases. The test statistic that we use is y conditional on $t = (x + y)$, and it has a hypergeometric distribution. (The test is often called Fisher's exact test for the 2×2 contingency table.) We compute the tail area

$$T_y = \sum_{u = max\,(u,t-n)}^{y} \frac{\binom{n}{t-u}\binom{m}{u}}{\binom{n+m}{t}} \quad \text{where } \max(0,t-n) \leqslant u \leqslant \min(m,t) \qquad \text{(A 1)}$$

and a lower prediction limit is given by

$$\text{the smallest } y\text{-value such that } Ty \geqslant \alpha \qquad \text{(A 2)}$$

and similarly for the other tail. Cox and Hinkley (1974, sections 5.2 and 7.5) discuss the test and the prediction of observations. The calculation of Ty is straight-forward, but tedious. You can write a computer program and it is easy to take what you need from a packaged program. The SAS-package, SAS (1982),

even has the so-called extended hypergeometric distribution, which reduces to the probabilities (A 1) in a special case. We call (A 2) the exact solution (although the level will not be exactly right since y only takes integer values).

If n and m are large, we can use the normal distribution as an approximation. Without the continuity correction we find, after simplification, that a test, which is two-sided and symmetric, leads to the following equation for the two prediction limits

$$\frac{\left(y - \frac{m(x+y)}{m+n}\right)^2}{\frac{mn(x+y)\quad(m+n-x-y)}{(m+n)^3}} = k^2 \qquad \text{(A 3)}$$

where k is the appropriate percentile of the normal distribution, for example 1.96 for a 95 % prediction interval, see Cox and Hinkley (1978). If we solve the equation, which is of the second degree in y, we find

$$y = \frac{\frac{mx}{n} + k^2\frac{m(m+n-2x)}{2n(m+n)} \pm \sqrt{k^2\frac{mx(m+n)\ (n-x)}{n^3} + k^4\frac{m^2}{4n^2}}}{1 + k^2\frac{m}{n(m+n)}} \qquad \text{(A 4)}$$

This solution has the structure

$$y = \frac{(A_1 + B_1) \pm \sqrt{A_2 + B_2}}{A_3 + B_3}$$

where B_i is small in comparison with A_i in may cases, for i = 1,2,3. If we neglect the B's and keep the A's only, we obtain

$$y = \frac{mx}{n} \pm k\sqrt{\frac{m(m+n)}{n}\ \frac{x}{n}\left(1-\frac{x}{n}\right)} \qquad \text{(A 5)}$$

We can view (A 3) as a first step with a 'statistical' approximation to (A 2), and (A 5) as a second step with a numerical approximation to (A 3). The approximations work well as a rule, if n and m are large and if x is not near the extreme values n and 0. We have made a few comparisons as shown in Table 1. The examples are those discussed in Sections 5.3, 5.4 and 5.6.

In Section 5.5 we have an example where $x = n$, and we use a one-sided test which leads to a lower bound on y. The approximations cannot be used. The exact expression (A 1) reduces fortunately to a single term, which is written explicitly in formula (4) in Section 5.5. The same thing happens again in Section 5.6.

Table 1. Comparisons of results obtained by using the exact solution and the approximations on bone material from the Eastern Trench.

Example/ 'Method'	Exact (A 1), (A 2)	Normal approx. (A 3)	Normal + numeric approx. (A 5)
Mammals	855 – 916	856 – 915	857 – 916
Fish	39 – 54	40 – 53	41 – 54
Small ruminants	1 – 20	1 – 19	0 – 17

If we study more than two species – for example roe deer, sheep and goat as in Section 5.6 – there are several possibilities. We can for instance construct prediction regions by successive tests for two species (bionomial distribution as before). An alternative is to consider the simultaneous distribution of all the species and derive a test. We have chosen the former method, since it is simple. The overall confidence level should also be computed, considering the numbers of the different species, but we have not done that so far.

The allocation can be illustrated graphically. With three species we could for instance use a triangle. In our example we have preferred a simple graph showing the fragment numbers of roe deer and sheep, and their relationship (Fig. 1). The number of goat fragments is obtained by subtracting the fragment numbers of sheep and roe deer from the total number, which is 278. We take a few values for roe deer within the prediction interval, regard them as fixed, and compute a prediction region for sheep (and goat at the same time). As an example $(7 + 1) = 8$ roe deer (corresponding to the lower bound) leads to $y \geqslant 196$, i.e. 258–270 sheep (and 0–12 goat).

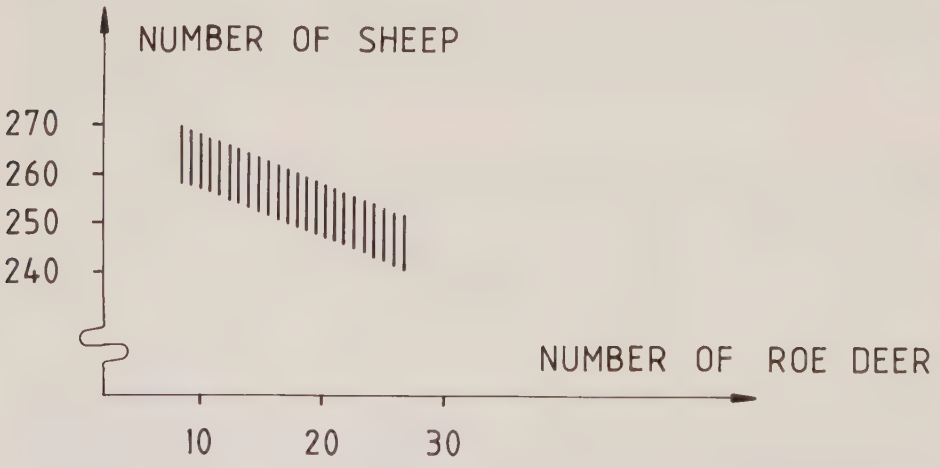

Fig. 1. Predictions regions for the fragment numbers of sheep and roe deer, when the formulae are applied to the fragment number of small ruminants, as described above and in Section 5.6.

References

Cox, D.R. and Hinkley, D.V., 1974: *Theoretical Statistics.* Chapman & Hall, London.
SAS User's Guide, 1982: *Basics,* 1982 Edition. Cary, NC: SAS Institute Inc.

Ebba During

THE FAUNA OF ALVASTRA

An Osteological Analysis of Animal Bones from a Neolithic Pile Dwelling

OSSA

ABSTRACT

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The Fauna of Alvastra. OSSA, Volume 12, 1986, supplement 1, XVI + 210 pages. Sundbyberg. ISBN 91-7146-349-6.

This study deals with the animal bones from the Alvastra pile dwelling, dated to about 3000 B.C. The site is situated in the calcareous Alvastra spring mire at Alvastra in the province of Östergötland, Sweden. The sample studied consists of more than 87000 fragments or 43 kg, that is, 6 % by weight of the total excavated bone material. It was collected from the Eastern Trench, excavated in 1976 – 1980. The total bone material from the Alvastra pile dwelling is one of the largest prehistoric osteological samples from the Swedish mainland. According to dendrochronological dating it accumulated during a very short time period, probably about 50 years. The excavations in 1976 – 1980 were undertaken with modern methods, including in particular water-sieving. The main part of the sample, 97 % by weight, consists of non-human bone remains within which about 61 % is unburnt, about 9 % damaged by fire and about 30 % is burnt. The remaining small part, about 3 % by weight, consists of unburnt human skeletal material, which is not analysed in this study. About 2 % of all the animal bones from the Eastern Trench show evidence of marks from butchery and skinning, while about 5 % show marks from mammal teeth and some show pathological or other changes.

The sample studied in detail is probably representive of material from the whole of the pile dwelling. Some of the bone material from the earlier excavations of the site have previously been analysed and differences and similarities are discussed with respect to the new results. The sample is investigated both qualitatively and quantitatively and certain problems related to taphonomy are discussed.

A large number of different species has been identified. The mammals are represented by 18 species and four major taxonomic groups, the birds by seven species and two major taxonomic groups and the fishes by eight species and one major taxonomic group. The site was used by a human population whose economy was based on both farming, hunting and fishing. The basis of the economy seems to have been the livestock.

Some actual problems related to quantification within the archaeozoology are examined, such as the estimation of the numbers of individuals of each species. Different methods are applied to the material and the results are noted and discussed. A new approach is established in order to allocate 'grouped material' to particular species. The procedure is based on a statistical model and aims at facilitating the quantification of the remains of species which are skeletally similar to one another (in this study restricted to mammals and fishes). The problem of distinguishing sheep from goat is especially treated in this respect.

The distribution and frequency of the bone elements from different skeletal regions are investigated species by species from a cultural as well as taphonomic point of view.

The ecology (and different biotopes) of the region which formed the resource area of the Middle Neolithic people of Alvastra are discussed with respect to the vegetational history of the area and the adaptive needs of each vertebrate species. One main purpose has been to establish whether hunting and fishing took place within the vicinity of the site or if long hunting expeditions were commonly neccessary. The relative frequency of various vertebrates in the material are discussed in detail. In this respect, the possibility of the occurrence of aurochs and pig in an early stage of domestication in the material is discussed. All results are then compared with mainly unpublished analyses of previously excavated material from the pile dwelling and partly with bone data from other prehistoric sites, both older, contemporary and younger, as well as with medieval and modern samples. Comparisons with the recent local fauna and biotopes are made.

An attempt is also made to establish the degree of seasonal activity at the site, by employing more accurate age assessment of the juvenile pigs, 'productive' and less 'productive' time periods for slaughter, hunting and fishing.

Preface

The work with this study has been undertaken at the Osteological Research Laboratory of the Department of Archaeology, University of Stockholm. From its inception my supervisor Professor Torstein Sjøvold has guided me. The discussions we have had have proved very stimulating. His views on osteology, methodological groups of problems and his statistical experience have been most valuable and facilitated my solutions of the problems which have arisen. I wish to thank him for the trust, support and unfailing interest in my work he had shown and which has contributed to the completion of this study. I would also like to express my gratitude to the founder of the laboratory, Professor em. Nils-Gustaf Gejvall. It was in fact his inspired lectures for archaeological students that aroused my interest in osteology. Ever since then, he has always shown interest in my work and shared his great knowledge with me, giving stimulation and good advice.

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With respect to the statistical model in the study, all the calculations have been done by Dr Eva Elvers at the Statistics Sweden. I wish to thank her for her invaluable contribution in this matter, as well as for her interest and willingness to listen and discuss statistical questions.

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I also wish to thank my friend and colleague Civ. eng. Carl-Göran Setterquist for his meticulously undertaken reading of the manuscript through which, from the beginning, many misprints were avoided. He also offered excellent help during the preparation of the final draft.

My research work has demanded a lot of literature, comprising the most various subjects. Indeed, it has not always been an easy task for the staff at the library of the Royal Academy of Letters, History and Antiquities to get them all, but they have always succeeded. I wish to thank everyone for their work and the wonderful service they have provided. Also, I want to thank the staff at the University library who, when required, also provided a very good service.

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Numbered list of bone materials used for comparison with the Alvastra bone material

1. **Alvastra,** Eastern Trench.
2. **Alvastra,** Hedell, L. 1910 and 1909–1913, 1919.
3. **Alvastra,** Ekman, J. 1977.
4. *'Stora förvar',* cave, Pira, A. 1926/27.

5a. **Troldebjerg,** Winther, J. 1935.

5b. **Troldebjerg,** Higham, C. & Message, M. 1969.

6. **Blandebjerg,** Winther, J. 1943.
7. **Bundsø,** Degerbøl, M. 1939.
8. **Lidsø,** Hatting, T. 1978.
9. **Ørum AA,** Winge, H. 1900.
10. **Aalborg,** Winge, H. 1900.
11. **Leire AA,** Winge, H. 1900.
12. **Aamosen,** Degerbøl, M. 1943.
13. **New Grange,** Wijngarden-Bakker, L.H. van 1980.
14. **Hötofta,** Lepiksaar, J. 1969.
15. **Voldtofte, Hillerød,** Møhl, U. 1957.
16. **Sorte Muld, Dahlshøj,** Møhl, U. 1957.
17. **Vejleby,** Winge, H. 1900.
18. **Borrebjerg,** Møhl, U. 1957.
19. **Eketorp II,** Boessneck, J. & Driesch, A. von den. 1979.
20. **Eketorp III,** Boessneck, J. & Driesch, A. von den. 1979.
21. **Lund,** Ekman, J. 1973.
22. **Slågarp,** Ekman, J. 1972.
23. **Møen Bog,** Winge, H. 1900.
24. **Inst. of Zoot., Stockholm,** Pira, A. 1926/27.
25. **Sweden, Atlantic Time** (red deer). Lepiksaar, J. 1978.
26. **Sweden, Boreal Time** (red deer), Lepiksaar, J. 1978.
27. **Great Britain (N, BA, IA, MA),** Noodle, B. 1982.
28. **Sweden** (modern red deer), Ahlén, I. 1965.
29. **Great Britain** (modern red deer), Noodle, B. 1982.
30. **Switzerland, N** (red deer), Lepiksaar, J. 1978.
31. **Eastern Europe** (modern red deer), Lepiksaar, J. 1978.
32. **Sweden, Mes** (red deer), Ahlén, I. 1965.
33. **Star Carr,** Noodle, B. 1982.
34. **Windmill Hill,** Noodle, B. 1982.
35. **Skara Brae,** Noodle, B. 1982.
36. **Denmark** (modern roe deer), Winge, H. 1908.
37. **Åloppe,** Pira, A. 1909.
38. **Gullrum,** Pira, A. 1909.
39. **Ringsjön,** Pira, A. 1909.
40. **Äs,** Lepiksaar, J. 1974.
41. **Kvarnby, Boberget,** Pira, A. 1909.
42. **Uppsala,** Pira, A. 1909.
43. **Bog Sites, Scania,** Pira, A. 1909.
44. **Segerbro, Arlöv I,** Lepiksaar, J. 1974.
45. **M N H, Gothenburg** (coll. modern wild boar), Lepiksaar, J. 1974.
46. **Switzerland, Bayern,** Pira, A. 1909.
47. **Ånneröd, Rörvik,** Pira, A. 1909.
48. **Sweden, Mes.** (wild boar), Lepiksaar, J. 1978.
49. **Switzerland, N** (wild boar), Lepiksaar, J. 1978.
50. **Sturefors,** Kurtén, B., pers. comm.
51. **Dyrhøjgårds Mose,** Richter, J., pers. comm.
52. **Galtrup Kaer,** Degerbøl, M. 1933.

53. **M N H, Gothenburg** (coll. modern brown bear), Broo, B., pers. comm.
54. **M N H, Gothenburg** (modern grizzly), Broo, B., pers. comm.
55. **M N H, Stockholm** and **D** of **Z, Stockholm & Uppsala** (modern brown bear), Kurtén, B., pers. comm.
56. **Sweden** (subfossil brown bear), Degerbøl, M. 1933.
57. **Denmark** (subfossil brown bear), Degerbøl, M. 1933.
58. **Norway** (modern brown bear), Degerbøl, M. 1933.
59. **Korsnäs,** Aaris-Sørensen, K. 1978.
60. **Denmark, Mes.** (badger, pine marten, wild cat), Degerbøl, M. 1933.
61. **Denmark** (modern badger, pine marten, coll. wild cat), Degerbøl, M. 1933.
62. **Estonia,** Paaver, K.L. 1965.
63. **Sweden** (modern badger), Degerbøl, M. 1933.
64. **The Baltic States** (modern badger), Paaver, K.L. 1965.
65. **The Baltic States, Sub-bor., Mes.,** Paaver, K.L. 1965.
66. **Sweden** (modern pine marten), Degerbøl, M. 1933 and Reinwaldt, E. & Erkinaro, E. 1959.
67. **Lithunia,** Paaver, K.L. 1965.
68. **M N H, Stockholm** (coll. modern wild cat).
69. **Denmark** (cat, *Felis catus*), Degerbøl, M. 1933.

Abbreviations

BA	= Bronze Age
coll.	= collection
D of Z	= Department of Zoology
EB	= Early Boreal time
IA	= Iron Age
Inst. of Zoot.	= Institution of Zootomy
LN	= Late Neolithic times
MES	= Mesolithic times
MN	= Middle Neolithic times
M N H	= Museum of Natural History
N	= Neolithic times
Sub-bor.	= Sub-boreal times

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REFERENCES

Ballance, P. F. 1964: Streaked-out mud ripples below Miocene turbidites, Puriri Formation. New Zealand. *Jour. Sed. Petrology 34,* Menash, Wisconsin.

Pettijohn, F. J. & Potter, P. E. 1964: *Atlas and Glossary of Primary Sedimentary Structures.* 370 pp. Springer-Verlag, Berlin, Göttingen, Heidelberg, New York.

Seilacher, A. 1963: Lebensspuren und Salinitätsfazies. *In* Unterscheidungsmöglichkeiten mariner und nichtmariner Sedimente. *Fortschr. Geol. Rheinl. Westf. 10,* 81–94. Krefeld.

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